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ABSTRACT

Developed by a group of university faculty members and graduate assistants, this planning guide is designed for teachers' use in high school, technical school, and associate degree agriculture programs in teaching nursery production with the focus on entry and advanced level occupations. This manual consists of the text of the student handbook plus suggestions for the teacher. Chapter topics, which include 84 subtopics, are: (1) Kinds of Nurseries, (2) Occupation in Nursery Production, (3) The Physical Plant, (4) How Plants Grow, (5) Propagation of Nursery Stock, (6) Growing Nursery Stock in the Field, (7) Growing Nursery Stock in Containers, (8) Marketing, and (9) How Managers Think. Each chapter contains stated learning objectives, key questions, key words, related information, suggested activities and resources, and a test. The material is illustrated with pictures and drawings. A list of references is given, and a list of recommended trees, shrubs, and flowers for school arboretums, information concerning the operation of tractors and farm machinery, and a calendar of nursery operations are appended. A related document, the student handbook, is available as VT 014 385. (GEB)

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NURSERY PRODUCTION

A Teacher's Manual

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Introductory Statement

Nursery Production--A Teacher's Manual, is one of a series of instructional aids prepared and edited by the Department of Agricultural Education through a contractual agreement between The Pennsylvania State University and the United States Office of Education, Division of Adult and Vocational Research. In addition to the development of instructional aids, the contract provided for 2 teachers' institutes in ornamental horticulture. The institutes were held July 5-22, 1966, and July 3-21, 1967.

The 54 teachers from the Northeastern States who participated in the teachers' institutes were asked to evaluate and helpimprove the organization and content of this instructional aid. They field-tested this unit with classes in their schools.

A special advisory committee has provided guidance in the selection of areas of emphasis for this unit of instruction. The committee has assisted by outlining key problem areas and by suggesting important subject matter information to be included. In addition to James E. Brewer, Jr., Chiko Haramaki, Robert P. Meahl, and Craig S. Oliver, who have been previously cited, the following persons have served in an advisory capacity in the development of this unit of instruction: Virgil E. Christensen, Center for Vocational and Technical Education, The Ohio State University; James R. DeTurk, Department of Landscape Architecture, The Pennsylvania State University; and Daniel E. Koble, Jr., State Department of Public Instruction, Delaware.

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The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

The preliminary draft of this publication was prepared and edited by the following staff members of the Department of Agricultural Education, College of Agriculture, The Pennsylvania State University: Graduate Assistant, William A. Robinson; Instructor, William J. Brown, Jr.; and Associate Professor, Gene M. Love.

The final draft was prepared and edited by the following members of the Department of Agricultural Education, College of Agriculture, The Pennsylvania State University: Graduate Assistants Sylvia Buckey, Taylor Byrd, Jesse S. Clemmons, Celdonia M. Gapasin, Douglas Hitchcock, and Freddie L. Richards; Instructor J. Robert Mercer; Associate Professor Richard F. Stinson; Professor Glenn Z. Stevens; Professor and Department Head, David R. McClay.

A number of persons gave technical assistance and reviewed the rough draft in whole or in part. Members of the Department of Horticulture, College of Agriculture, The Pennsylvania State University, who helped in this way are: James E. Brewer, Jr., Assistant Professor; Chiko Haramaki, Associate Professor; Robert P. Meahl, Professor; J. Robert Nuss, Jr., Assistant Professor; Craig S. Oliver, Associate Professor; and Darrell E. Walker, Professor and Department Head. Additional persons who helped in this way are: Roy A. Mecklenburg, Associate Professor, Department of Horticulture, Michigan State University, East Lansing, Michigan; Earl F. Ervey, Sales Manager, The Conard-Pyle Co., West Grove, Penna.; Sidney B. Hutton, Jr., President, The Conard-Pyle Co., West Grove, Penna.; and Ray Brush, Secretary of the American Association of Nurserymen, Washington, D.C.

Special acknowledgement is due both The Conard-Pyle Co., of West Grove, Penna., and Princeton Nurseries, of Princeton, N.J., who loaned many of the photographs used in this publication and permitted free access to their properties for photographic purposes.

Photographs not otherwise acknowledged were largely the work of Graduate Assistants Christopher Shelley and Taylor Byrd, and Instructor Richard W. Tenney. Drawings not otherwise acknowledged were made by Susan Eagles and William L. Hadden. Typing was by Trudy G. Orner and Cathy Brown.

Where trade names are used, no discrimination is intended, and no endorsement is implied.

Teaching the Unit

Nursery Production has been written for upper high school and post high school students interested in entering careers in this business. It can be used either for students exploring careers in nursery production or for students developing or improving their skills in this area. It should be accompanied by a course in identification of woody ornamental plants. Studying this unit, Nursery Production, would also be useful to students planning for careers in landscape contracting, landscape-nursery, landscape maintenance, landscape design, and garden centers.

Nursery production is an important agricultural business in the Northeastern United States. Before teaching this unit, it would be useful to determine the nursery employment possibilities in the area served by the school as well as the county in which the school is located. Interviews with nurserymen will familiarize teachers with requirements for employment and job opportunities, as well as provide business contacts that are valuable in carrying out work experience programs.

This unit was written primarily from the standpoint of the production of nursery crops. Most nurseries are landscape-nurseries, in which the firms not only produce many of the plants they sell, but also make landscape plans and execute them. Students preparing for careers in landscape-nurseries should also receive instruction in landscape design, landscape maintenance and establishment, and identification of woody ornamental plants. Studying elementary plant physiology, plant science, soils and fertilizer, and the elements of human relations are highly recommended.

Students aspiring to managerial positions in a nursery should be advised to obtain 2 to 3 years of practical experience and then enroll in a 2-year, post high school, or associate degree program at one of the institutions listed in National Survey of Post High School Vocational Horticulture Training 1969, a copy of which may be obtained from the American Association of Nurserymen, 835 Southern Building, 15th and H Streets, Washington, D. C. 20005.

Supervised occupational experience programs should be included as an integral part of the instructional unit. This experience is valuable for advanced students who should be provided with a transition from "learning

by doing" in a school setting to "learning by doing" on the job. This experience will also help them in developing good work attitudes. Nursery businesses selected for this purpose should be those which will provide the greatest possible range of experiences in the particular areas of emphasis in this instructional unit. Successful occupational work experience programs are developed only if carefully planned, and only if sufficient time is scheduled for on-the-job supervision by the teacher. Before the school year begins, arrangements should be made for placing students. A definite understanding among the employer, the student, his parents, and the teacher, in regard to hours, wages, responsibilities, duties, and skills is a key to successful work experience programs. The teacher, student, and employer together should develop a check-off list of experiences the student is to have. These should be reviewed frequently during the occupational experience program.

The school nursery should be operated as a laboratory that simulates commercial production. Crops of bare-root plants, balled and burlapped plants, and container stock should be planned for and marketed at the major spring and fall marketing periods. Until a student can satisfactorily perform most of the skills and tasks in this manual, and has developed the ability to work well in group work, he is not ready for work experience placement.

A "Teacher's Resource Kit," consisting of 32 publications from the American Association of Nurserymen, (many of them references in manual) may be obtained at a special educators rate of $15 from: The American Association of Nurserymen, 835 Southern Building, 15th and H Streets, Washington, D.C. 20005.

This Teacher's Manual consists of the text of the Student Handbook plus suggestions to the teacher. Suggestions to the teacher have been included on green paper at the end of each problem area. The page numbering of both publications is identical. In planning to teach a problem area, the teacher may wish to proceed as follows:

1. Read the text material.
2. Obtain the references recommended.
3. Select and order visual aids and supplies.
4. Read the suggested student learning activities.
5. Before teaching the unit, review the key questions to be emphasized.

NURSERY PRODUCTION

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CHAPTER 1

KINDS OF NURSERIES

Learning Objectives

1. To become aware of the size of the nursery industry in the U.S.
2. To understand how the nursery industry developed in the U.S.
3. To recognize the difference between a retail and a wholesale nursery business.
4. To become aware of the different types of businesses within the 2 major categories of the nursery industry - wholesale and retail.
5. To become familiar with the activities involved in the production and distribution of nursery stock.

Key Questions

1. What is the function of a wholesale nursery?
2. How do wholesale nurseries sell their products?
3. What is the difference between a nursery salesman and a nursery sales agent?
4. What is the function of a nursery retailer?
5. How did the nursery industry develop in this country?
6. How do mail-order nurseries differ from other nursery retailers?
7. Why have garden centers become an important marketing outlet for nursery stock?
8. How does a landscape nursery differ from other retailers of nursery stock?

Key Words

Annuals - plants that complete the life cycle, from seed to seed, in one season

Biennial - annual plants that require exposure to the winter season before they can flower

Bulb - an enlarged underground part of a plant composed mostly of enlarged leaf-like scales (tulip)

Consumer - a person who consumes ("uses up") a product

Corm - an enlarged underground part of a plant composed mostly of stem tissue (gladiolus)

Cultivar - a population of identical plants (the same thing as "variety")

Cutting - a part of a plant, usually a stem or root piece, that is induced to produce roots and to grow into a new individual plant

Design - to draw a plan on paper to scale so actual measurements can be converted from it

Groundcover - a low-growing, spreading plant

Herbaceous - soft stemmed

Liner - a small plant of suitable size for planting in rows (lines) in a nursery

Nursery - a business firm that propagates, grows, and sells trees, shrubs, vines, and flowering plants; it may engage in any one or all of these activities

Perennial - a plant that lives for several to many years

Seedling - a small plant grown from a seed

Stock - saleable products; in a nursery, "stock" refers to plant material

Transplant - a young plant of suitable size for planting in a permanent position (about 2 to 4 inches tall)

Kinds of Nurseries

The nursery business, as defined by the American Association of Nurserymen, refers to the production and/or distribution of plant materials, including trees, shrubs, vines, and other plants having a persistent woody stem or stems, and all herbaceous annuals, biennials, or perennials generally used for outdoor planting, by those companies whose major activities are agricultural or horticultural. It includes such business activities as the planting and sowing of landscaped areas. Although nurseries in the Western and Southern states produce and sell vegetable and annual flower transplants, in the Northeastern states these are usually produced by greenhouse firms that distribute them through retail nurseries, garden stores, and chain stores.

This Chapter discusses the importance of nurseries in the United States, how they developed, and some details about the kinds of wholesale and retail nurseries.

Importance of the Nursery Industry

The 1969 census figures for the value of nursery crops will probably not be available until some time in 1972. At that time it will be interesting to compare them with the following information from the last census, taken in 1959 (see page XXV of Reference 49).

Table 1. Wholesale value of three groups of nursery stock in 1959.

Groups of Nursery Stock	Wholesale Value
Lining out stock	$ 8,000,000
Ornamental plants	$125,000,000
Fruits and nuts	$ 22,000,000
Total	$155,000,000

While the total value has certainly increased in the last decade, (10-year period), it would be difficult to predict relative increases or decreases among the three groups.

The 1959 census showed that 3 Northeastern states,--Pennsylvania, New York, and New Jersey were among the 10 leading states in numbers of nurseries. Table 2 shows the ranking of these 10 states. (This is from pages 3 and 4 in Reference 49). There were 6,757 nurseries in the United States in 1959.

Table 2. Ranking of the 10 leading states in numbers of nurseries in 1959.

State	Number of Nurseries	Percent of U.S. Total
California	712	10.5
Florida	684	10.1
Texas	424	6.3
Pennsylvania	409	6.1
Ohio	408	6.0
New York	387	5.7
New Jersey	329	4.9
Michigan	327	4.8
Illinois	251	3.7
Oregon	237	3.5
Total		61.6

It is interesting to see that nearly 62 percent of the nurseries in the United States were located in only 10 of the 48 states in 1959.

The Northeastern states accounted for over ¼ of the numbers of nurseries in the U.S., and for about 1/8 of the value of crops grown in 1959, according to Table 2. These figures are from pages 3 and 18 in Reference 49.

More recent national figures for 1966 from Reference 40, Scope of the Nursery Industry 1968, indicate a wholesale dollar volume of 525 million, and a retail dollar volume of 1.6 billion. Employment in the nursery industry in the United States in 1966 was 50,000 permanent employees with 110,000 at seasonal peaks. Table 3, below, shows the kinds of U.S. nurseries, their percentage numbers, and percent of dollar volume for 1966 as reported in Reference 49.

Table 3. Kinds of U.S. nurseries, their percentage numbers, and percent of dollar volume for 1966.

Kind	Percent of Firms	Percent of Dollar Volume
Wholesale	37%	42%
Landscape	32%	24%
Garden Center (Plants)	15%	9%
Unclassified	6%	7%
Garden Center (Other)	5%	4%
Maintenance Firms	3%	1%
Retail Mail Order	2%	13%

Development of the Nursery Industry

The first commercial nursery on the North American Continent was established in 1730 at Flushing, Long Island, N.Y., by Robert Prince. He obtained his seeds and cuttings of ornamental trees and shrubs from the French Huguenots who brought them to the Western Hemisphere. Four generations of Princes kept the nursery in operation for a period of 125 years.

From 1750 to 1850 the nursery industry expanded slowly along the Atlantic Seaboard and toward the West.

The first evergreens to be grown commercially were raised by Robert Douglas, in Illinois, in 1844.

The practice of keeping nursery stock over winter in a cellar storage, which revolutionized the nursery industry in the United States, was introduced by William Heikes, in Alabama, around 1850.

Figure 1. Horticulture students at The Pennsylvania State Agricultural College about 1900.

The markets for nursery stock expanded with the development of improved transportation in the form of canals and railroads in the early part of the 19th century.

Early nurseries produced mostly fruit trees for farm orchards. These were sold by traveling salesmen who went from farm to farm. Plant orders were shipped by rail or canal, and the agents were given a percentage of the amount collected.

During the 1920s the demand for shade trees, shrubs, and roses began to equal, and finally surpass, the demand for fruit trees. The development of the parcel post system and Rural Free Delivery during this period made it possible for customers to order and receive nursery stock by mail. The rates were low, and large packages could be sent by mail. During this time the mail order nursery business increased rapidly. It is still an important marketing channel for nursery stock.

The Depression of the 1930s led nurserymen to start marketing through department stores and discount houses. To keep the plants in fresh condition for sale, they were wrapped in waterproof paper with moist packing material around the roots.

The development of garden stores came after World War II. They became popular because they eliminated the necessity for stopping at a hardware store for seeds, fertilizer, and handtools, at an equipment dealer for garden equipment, and at a nursery for plants. The garden store provides "one stop" shopping.

The following sections on "Wholesale Nurseries" and "Retail Nurseries and Retail Outlets" are written as though there were sharp distinction between these functions. This was done to help give a clear picture of how nursery plants are marketed. Some businesses may serve as wholesale growers, agents, and jobbers all at the same time. Some wholesale grower

nurseries also operate garden stores and mail order businesses in addition to selling plants wholesale.

Wholesale Nurseries

Wholesale nurseries produce and/or sell stock to other producers and to retailers. They do not sell directly to ultimate consumers.

Wholesale Grower Nurseries produce most of the stock grown in the nursery industry. The function of the wholesale nursery is to grow nursery plants to marketable size and to sell them in large lots to retail outlets through its own salesmen or through agents, brokers, or wholesalers. Wholesale growers grow large quantities of a wide variety of plants. Many grow over 200 different species and cultivars of plants. They produce shade trees, flowering trees, evergreens, shrubs, vines, groundcovers, fruit trees, grape vines, berry plants, perennials, and rose plants.

The nurserymen in a wholesale business sell their products by mailing price lists to members of the nursery industry. These lists consist of items offered for sale, together with their prices. These lists sometimes include descriptions and uses of the plants.

Other wholesale nurserymen sell their products through advertisements in trade journals,--publications devoted to the interests of the industry. Still another method used by businessmen is by means of salesmen who call on members of the trade. These men are well qualified for their jobs. They are familiar with the plants they have for sale and their uses, render valuable services to their customers, and pick up many useful ideas in their travels which they can share with others. They also collect market information which is of great value to the management.

The establishment of a wholesale nursery business requires a large amount of money, which is needed for buying land, constructing offices, storage rooms, greenhouses and irrigation equipment. Trucks, tractors, and machinery are also needed in the nursery operation of planting, cultivating and harvesting.

Wholesale Grower Specialists limit their production to a particular kind of plant, or a particular group of plants. There is a trend toward increasing numbers of this kind of nursery. Some nurseries produce only roses; others, only broad leaf evergreens, or groundcovers,

plants, or shade trees. There are propagation specialists who sell only rooted cuttings, seedlings, or liners. Some wholesale grower specialists produce only container-grown plants.

KOELREUTERIA paniculata. 25'-30' (Zone 5) — **Varnishtree**

Bright yellow flowers in July. A very valuable and attractive small tree. Also called Goldenrain-tree.

5 to 6 ft.	7.20	5.80	4.80
6 to 8 ft.	10.75	9.00	7.20
8 to 10 ft.	14.00	11.50	9.30
9 to 11 ft., 2 to 2½ in., B&B	39.65	34.55	.....
9 to 11 ft., 2½ to 3 in., B&B	48.30	42.00	.....
10 to 12 ft., 3 to 3½ in., B&B	80.10	69.60	.....

KOLKWITZIA amabilis. 6'-8' (Zone 4) — **Beautybush**

A distinctive vivid, clear pink flowering shrub. Very effective.

18 to 24 in.	1.10	.75	.60
2 to 3 ft.	1.50	1.10	.90
3 to 4 ft.	1.85	1.45	1.20

—L—

LABURNUM vossi (watereri). 18'-20' (Zone 5) — **Goldenchain**

This is a selected hybrid of vulgare with larger and showier flower clusters. One of the most beautiful and popular spring flowering trees.

5 to 6 ft.	6.30	5.25	4.20
6 to 8 ft.	8.55	7.15	5.70
8 to 10 ft.	11.70	9.75	7.80
10 to 12 ft., 2½ to 3 in., B&B	48.30	42.00	.....

LARCH (See LARIX)

LARIX europaea (decidua). 50'-60' (Zone 2) — **European Larch**

Grows rapidly. Especially good for spring effects.

2 to 2½ ft., 8-in. cans	4.70	3.70	.....
8 to 10 ft., 2½ to 3 in., B&B	44.50	38.65	.....
10 to 12 ft., 3 to 3½ in., B&B	73.00	63.50	.....

Figure 2. A wholesale nursery price list.

A Nursery Salesman is employed by the producing nursery company and is paid an annual salary or a commission (percentage of the value of each sale) or both. He makes sales to other nurseries and retailers. He may or may not be assigned a geographical area ("territory") to cover. His travel expenses are covered by the company He sells only at prices set by the company, which usually include a discount for large quantities.

Wholesale nurseries also have a "home office" salesman who handles telephone orders, mail orders, and completes sales to persons who call at the nursery sales office. The "home office" salesman very often also functions as the sales manager for the firm.

A Nursery Sales Agent or Sales Representative is an independent salesman who enters into a contract (agreement) to represent the nursery, usually within a "territory." He sells the stock at prices set by the producing nursery. He is not on a salary, but receives a 5 to 10 percent commission for his services. He pays all of his own expenses. Although he may or may not have the plants in his physical possession, he does not take title to them. "Title" refers to ownership. Legally, the plants are "owned" by the producing nursery until they have been sold. When sold, ownership goes to the purchaser. The nursery sales agent takes orders from nurseries and retailers and fills them with stock that he has on hand, or more frequently, forwards the orders to the producing nursery he represents, which then ships the ordered stock directly to the purchaser. A nursery sales agent actually performs only the selling function in the marketing process, and has no other obligation to either buyer or supplier.

A nursery sales agent may have contracts with several nurseries at the same time. His office could be 2000 miles or more from the nursery (or nurseries) he represents.

A Nursery Jobber is a firm employing salesmen as full time employees. This firm may operate in one or both of two different ways.

It may purchase and take physical possession of large lots of nursery stock from wholesale nurseries. This stock is then sold in smaller lots to other nurseries, landscape contractors, garden stores, and other retail outlets (this is known as "re-wholesaling"). The nursery jobber tries to get the best price it can; the mark up is often 35 to 40 percent or considerably higher.

Another way in which a nursery jobber may function is to sell stock for wholesalers at the regular wholesale price, for which a commission of 20 to 25 percent is received. In this instance the jobber does not take physical possession of the stock, but it is shipped directly from the producer to the purchaser. However, this performance differs from that of the nursery agent (or nursery representative) in that the nursery jobber assumes credit risk and responsibility for any adjustments that might have to be made.

The nursery jobber almost always represents many wholesale producers, sometimes even competing ones.

The salesmen employed by the jobber work on a salary or commission or both.

Wholesale growing nurseries will often purchase large lots of plants of certain kinds from other wholesale growing nurseries to fill depleted stock or to have plants on hand of certain species which they do not grow themselves. In a limited sense, then, a wholesale growing nursery may occasionally perform some of the functions of a nursery jobber.

Retail Nurseries and Retail Outlets

Nursery stock may be sold retail by landscape nurseries, garden stores, or non-nursery outlets. Some chains of garden stores and mail order businesses are owned and operated by large wholesale grower nurseries.

Figure 3. A landscape nursery designs and executes landscape plans.

The Landscape Nursery sells and plants landscape jobs. It may design landscape plans or follow plans made by a landscape designer or landscape architect. These firms may offer a complete service in preparing the landscape plans and executing them. Many landscape nurseries grow some of their own stock, but the trend is to merely purchase finished stock and hold it in shaded beds until it is sold. The landscape nursery often "special order" plant material for large landscape jobs. The equipment needed includes trucks, tractors, tillers, hand tools, and special machines for handling large trees. Some landscape nurseries also offer maintenance services, usually at a monthly or annual rate. A landscape nursery usually has an office for record keeping and for the convenience of customers, but the sale of most landscape jobs takes place in the customer's home.

A Landscape Contractor is a specialized kind of landscape firm. It does not prepare landscape plans, but executes the plans designed by a professional landscape architect or designer. The landscape contractor constructs pools, steps, walls, walks, and terraces according to the plan, and purchases and plants the trees, shrubs, and other plants specified in the plan. The landscape contractor is often concerned with large projects, such as highways, industrial plants, commercial buildings,and municipal parks, but also handles private residences and small businesses as well.

Some landscape contractors do primarily landscape maintenance of institutional, business, or private residential grounds. This is often done on a monthly fee basis, and may include such off-season activities as snow removal. Sometimes maintenance contracts include the occasional replacement of shrubs or trees when appropriate.

A few landscape contractors supply and maintain large containers of trees, shrubs, and flowers for shopping centers or other businesses on a rental basis. This is being done extensively on the west coast.

An additional service offered by some landscape contractors is that of installing and maintaining indoor landscapes for shopping centers, institutions, and businesses. There is a trend toward increased use of this kind of service. The persons involved in this work must be trained in the special construction problems involved and must know the appropriate tropical plants to use and the special maintenance techniques that are required.

Garden Stores or Garden Centers are important in nursery retailing. In quantity of stock sold, garden centers and garden departments in chain stores sell more nursery stock than landscape nurseries and landscape contractors. Garden stores sell nursery plants, seeds, bulbs, roses, vegetable and flower transplants, fertilizer, mulching materials, pest control materials, tools, equipment, outdoor furniture, and outdoor ornaments.

Figure 4. A garden store offers "one stop" shopping.

The garden store is housed in a building for displaying the products and protecting them from the weather. The nursery stock is held in an outdoor area, usually beds under lath or woven plastic cloth sun shade. It sometimes has greenhouses for displaying house plants, potted plants, and vegetable and flower transplants.

Garden stores vary in their operation. Some are strictly "cash and carry;" while others extend credit, make deliveries, and may even offer landscape design and planting services. There are self-service garden stores, similar to supermarkets in their operation. Others have sales personnel who give technical information and guide customers in the selection

of merchandise. Some chains of garden stores have over 30 outlets.

Mail Order Nurseries are third in the volume of nursery stock when compared with garden stores and garden departments in chain stores, and with landscape nurserymen and landscape contractors. Many mail order nurseries have also begun to sell fertilizer, pest control materials, and small tools and equipment. Millions of free, colorful catalogs are mailed to prospective customers early each year. There is usually a small charge for the more elaborate catalogs. The plants are shipped to the customer by parcel post or express at the appropriate planting time for his particular location. Currently, about 15 firms are doing about 80 percent or more of the mail order business. Many are using computerized methods in order to keep competitive with other kinds of retail nurseries.

Figure 5. Mail order selling of nursery stock has been important for about 70 years.

Non-nursery outlets sell a high volume of nursery stock. Some kinds of non-nursery outlets that sell nursery plants on a short time seasonal basis are grocery, hardware, department, variety, florist, and drug stores, as well as produce stands and farmer's markets. Sales are usually strictly

"cash-and-carry," only inexpensive plants are sold, and the quality is often not good.

Some department store chains have "garden" or "plant" departments that are operated on a year around basis. They often sell nursery stock along with other kinds of plants, supplies, and equipment. These departments often lack facilities for proper care of the plants, and frequently lack personnel well qualified to answer customer questions. However, some departments do have appropriate facilities that are well managed and offer excellent products and services.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

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Suggested Learning Activities

Arrange for a class trip to several wholesale nurseries and several retail nurseries so that students may observe the production of nursery stock, as well as management and retailing in the nursery industry. Pre-arrange for students to ask questions in an interview with the manager of each business. Follow the trip with class discussion of what was learned.

Test

1. What is a nursery?
2. What percent of U.S. nurseries is located in Northeastern States?
3. Where did nurseries first become established in this country?
4. How did canals, railroads, and parcel post help the nursery industry?
5. What kind of nursery produces most of the nursery stock?
6. How does a wholesale grower specialist nursery differ from a wholesale nursery?
7. How is a nursery salesman paid?
8. How is the work of a nursery agent different from that of a nursery salesman?
9. Describe the two ways a nursery jobber sells plants.

10. How does a landscape nursery differ from a landscape contractor?
11. List at least 10 kinds of items offered by garden stores.
12. How does non-nursery outlet retailing of nursery stock differ from garden store selling of nursery stock?
13. From the standpoint of the customer, what are the advantages of obtaining plants from a mail order nursery?

CHAPTER 2

OCCUPATIONS IN NURSERY PRODUCTION

Learning Objectives

1. To learn about the kinds of occupations in the nursery business and the duties and responsibilities of each.
2. To learn about the kinds of education and experiences needed for each occupation.

Key Questions

1. What categories of jobs exist in the nursery business?
2. What skills are needed by people in nursery occupations?
3. How can one learn these skills?
4. Which occupations are prevalent in your local area?

Key Words

Crew - a group of men working on one job or under one foreman

Details - attention to praticular items

Entomology - the study and control of insects

Peak work loads - a period when labor is in great demand

Pathology - the study and control of diseases

Policy - a procedure or method used to guide and determine present and future decisions

Promoting - to help bring (as an enterprise) into being

Propagation - producing new plants from parts of whole plants, or from seeds

Skilled - ability to use one's knowledge effectively in performance

Stockholder - one of the owners of the capital (invested money) that a firm uses in the conduct of a business

Tolerance - the maximum amount of a pesticide residue that may lawfully remain on or in plants

Unskilled worker - one who lacks training in the performance of a particular occupation

The Nursery Business as a Career

The nursery business may have a satisfying and rewarding position for you if you have the interests and can develop the abilities needed.

People who have been successfully employed in nurseries have an interest in plants, enjoy outdoor work, and like people. They also are honest and have an even disposition, are willing to work (at times--hard), and are willing to assume some responsibility. The ability to use imagination and to take the initiative in getting things done usually results in advancement in position. There are rewarding positions for those with sales ability. Those with a well-developed artistic sense may find landscape-nursery work especially interesting and satisfying.

After reading about positions in the nursery business on the following pages, you may wish to do some further reading about the careers of some successful nurserymen in chapter VIII, p. 75-87 in Reference 51. Your Future in the Nursery Industry. Chapter IX, p. 88-94 tells about satisfactions, while Chapter X, p.p. 95-99 gives the disadvantages of this business. Chapter XII, p.p. 111-124 gives suggestions for planning a career in the nursery business. Chapter XIII, p.p. 124-127 gives some good tips on applying for a job in a nursery business.

Organization charts, figures 6, 7, and 8, pages 29 and 30 indicate the lines of responsibility among the positions in several kinds of nurseries.

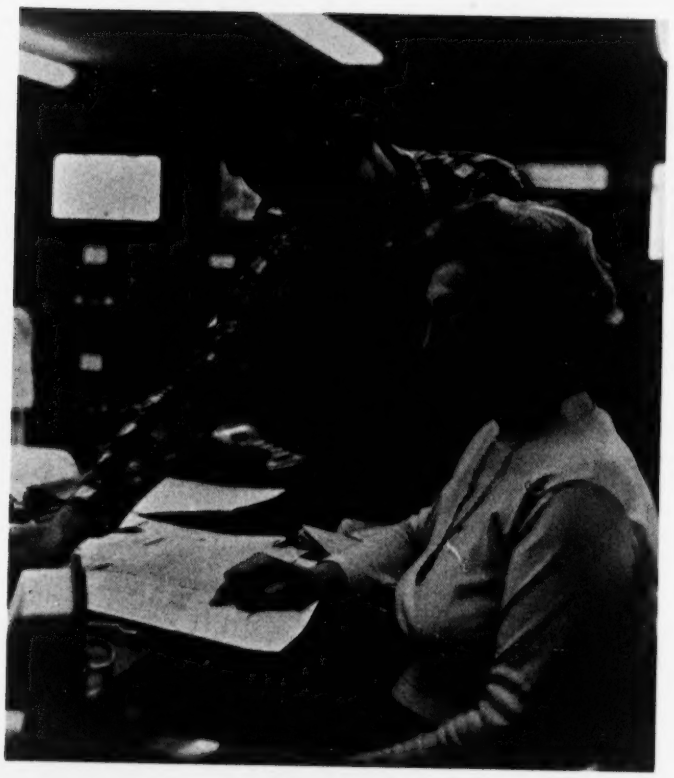
Nursery Worker

A nursery worker is under the supervision of a nursery foreman and needs to know plant material and the cultural techniques required. He needs to know how to operate the special equipment used in the nursery business. He must be able to work effectively with a group of people and be interested in some "on-the-job training."

Some nursery workers have not finished high school, while many are high school students gaining work experience, and some are high school graduates with training in ornamental horticulture.

A nursery worker usually receives from $3,500 to $5,000 per year. Temporary, unskilled workers are often hired at times of peak work loads, such as fall digging of deciduous stock to be stored over winter.

Nursery Clerk-Typist



A nursery clerk-typist is directly responsible to the office manager or to a head secretary. Her duties may include writing letters, billing, filing, and answering a telephone. She may do some bookkeeping. She should be able to spell plant names correctly and should know nursery terminology. The salary range is from $4,000 to $8,000, depending upon experience and responsibilities.

Nursery Salesman

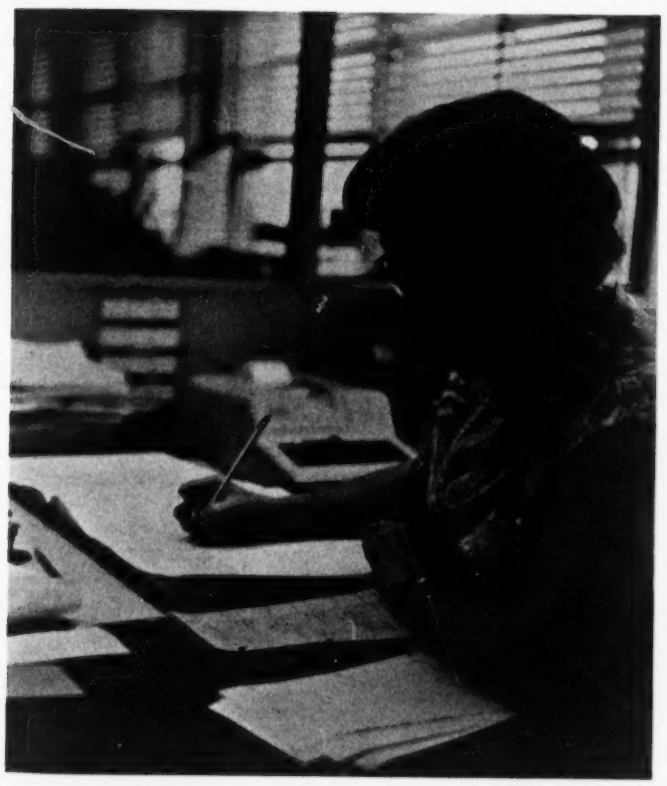
A nursery salesman is directly responsible to the office manager.

A nursery salesman needs to know the identy of all the woody ornamental plant material produced by his firm and appropriate uses for it. He needs to know what sizes and grades are in stock and the current prices. He must have sales ability and enjoy selling.

Most salesmen are high school graduates with training or experience in selling and in nursery work. Some are graduates of two-year, post high school programs, while many hold B.S. degrees.

A nursery salesman may earn from $5,000 to $10,000 a year or more. Many are employed on a base salary, with the potential of a commission on sales beyond a base annual sales volume. Others are employed on a salary only, while others are on a commission only.

Stock Man



The stock man keeps accurate records of what plants went into storage, saleable stock in the field, what has been sold, and what is on hand. He is directly responsible to the sales manager. He checks regularly with the storage manager and the production manager to make certain their records agree. All orders pass through his hands so that he can maintain records that are accurate on a day-to-day basis. A detailed knowledge of the nursery business is not necessary, but a stock man must be familiar with the names of the plants and grades and sizes. This position requires meticulous attention to details. Women are sometimes employed in this position. The salary range is from about $5,000 to $10,000 per year.

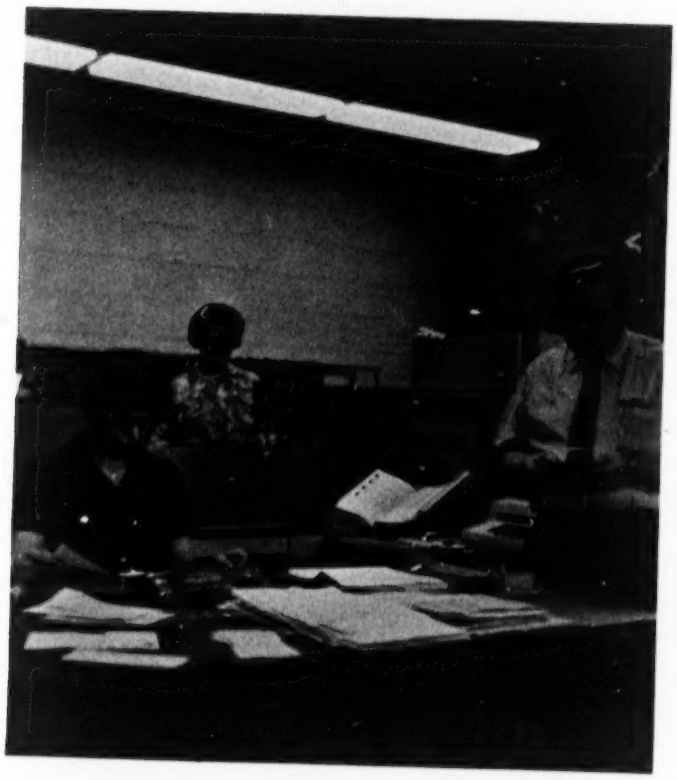
Nursery Foreman

A nursery foreman is in direct charge of a crew of nursery workers. He is responsible to the nursery production manager. He must know woody plant material well, and the cultural techniques of fertilizing, spraying, planting, pruning, and harvesting. He must be able to recognize symptoms of insect, disease, or other signs of unhealthy plants. He must know how to maintain and repair the specialized equipment used in the nursery business. He must know how to work harmoniously with a group of men.

Many nursery foremen have had no formal training beyond high school, but have had years of practical experience. Increasing numbers of them have had post high school training in ornamental horticulture together with work experience.

The salary range is from $5,000 to $8,000.

Office Manager

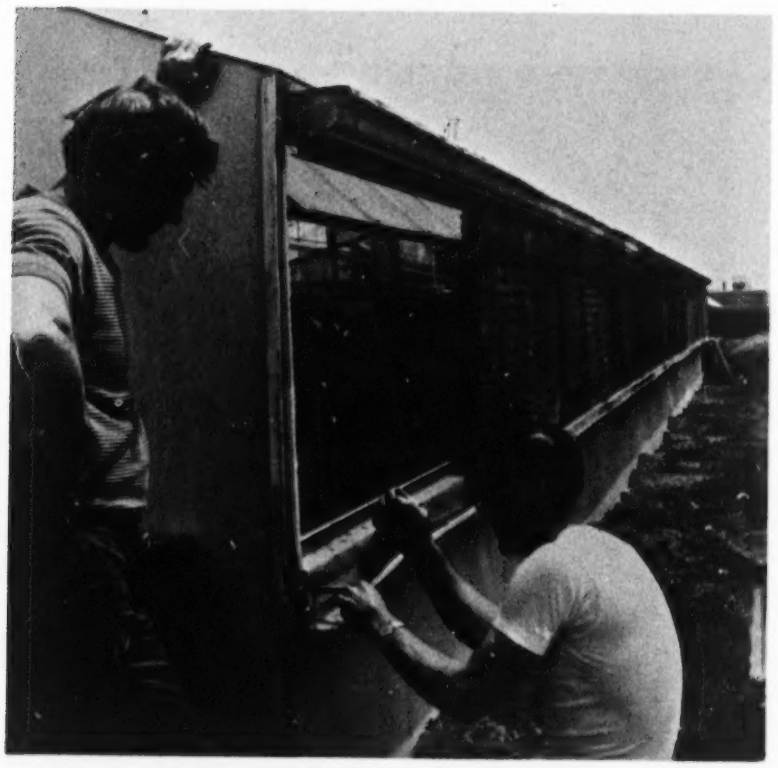


A nursery office manager is in charge of promoting and selling nursery stock. He is directly responsible to the nursery superintendent, or the nurseryman. He must have an intimate knowledge of plant material, quality, grades, costs, and prices of competitors. He must know the needs of his market as well. He must know sales methods and techniques and how to help his sales force accomplish their goals. He has direct charge of a group of salesmen. He is also responsible for purchasing, and supervises an office staff.

The nursery office manager has had several years of training beyond high school, not only in the nursery production but also in salesmanship. Office managers nearly always reach that position only after having had experience as successful salesmen.

The salary range is from $5,000 to $15,000.

Physical Plant Manager



The physical plant manager of a nursery supervises the repair and maintenance of all buildings, grounds, and equipment. He is directly responsible to the nursery superintendent or the nurseryman. While he needs to know the uses to which plants are put, it is not essential that he know the fine details of plant culture.

He must be prepared to do major repairs to the heavy specialized machinery used in the nursery business such as sprayers, diggers, and herbicide applicators. In many cases, nurseries construct adaptations of standard farming equipment such as tractor-drawn root pruners.

He must know building repair, as well as plumbing, heating, refrigeration, and electrical repair. He maintains a check-off list of regularly recurring maintenance jobs, such as oiling motors, checking accuracy of thermostats, etc.

In a small nursery he may do this work himself with a helper or two. In a large nursery he may supervise a number of foremen, each with his own crew of maintenance and repairmen. His salary may range from $5,000 to $12,000.

Storage Manager

The position of storage manager is found in large nurseries. He is directly responsible to the nursery superintendent, or the nurseryman. His duties may be performed by the production manager in smaller businesses.

The storage manager must know the appropriate time for digging deciduous plant material and the appropriate storage temperature and handling technique for each kind of plant. He must plan his schedule to have an orderly inflow and outflow of plant material. He must overcome disease problems in storage. He must supervise grading and packing of the material and maintain the equipment required in this phase of the operation.

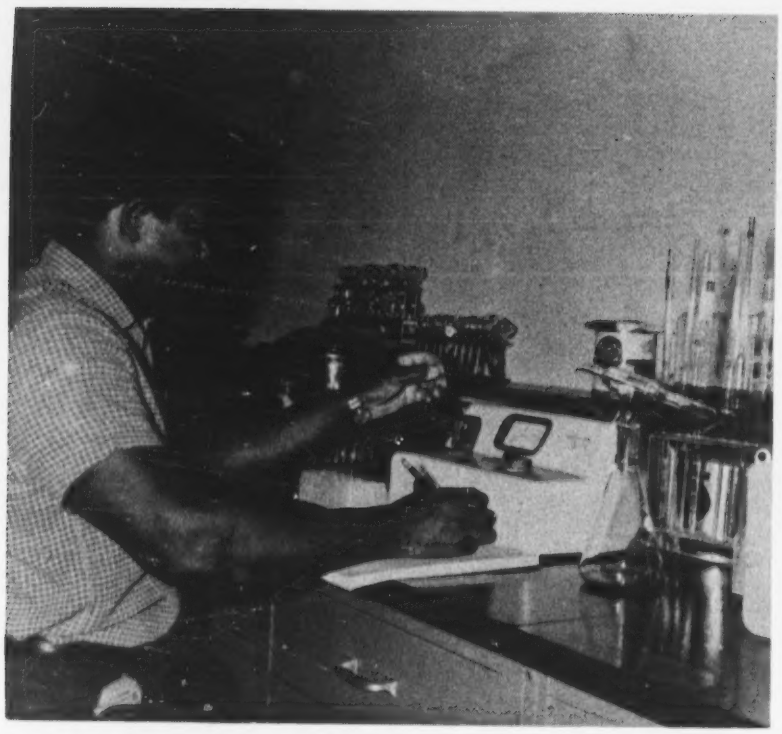
The storage manager has usually had training beyond high school, and has had several years of experience.

His salary may range from about $5,000 to $10,000.

Plant Breeder

Large nurseries sometimes employ plant breeders. These people are directly responsible to the nurseryman or nursery superintendent. Their task is to develop new cultivars that are superior in growth rate, adaptability, pest resistance, color, fruit, or form to those already in use. In the past, plant breeders have developed superior cultivars of roses, and more recently, their attention has turned to fruit trees, shade trees, and shrubs. A plant breeder usually has a Master of Science degree or a Doctor of Philosophy degree. He has had training in plant science and genetics. It essential that he have a thorough knowledge of the nursery business and a detailed knowledge of plant taxonomy. He may have one to several assistants. His salary may range from $8,000 to $18,000 per year.

Nursery Technician



A nursery technician is directly responsible to the nursery superintendent, or the nurseryman, but he works closely with all the managers. He is usually responsible for making recommendations for fertilizer applications, and pest and weed control measures. He often helps supervise these activities.

He must be skilled in soil sampling, and soil testing; must know the nutritional requirements of all crops in the nursery; must be able to set up a fertilizer program and checks up on its effectiveness.

He must be able to identify insect and disease problems at an early stage and must know the most recently developed techniques and materials for controlling them, and know the tolerance of the nursery stock to pesticide materials.

He must know the identity of troublesome weeds and when and how to control them without damage to the crop plants. He must know the newest herbicide techniques and materials.

The nursery technician is also often considered the "trouble shooter," and may be given knotty cultural problems to solve.

This position requires a person with good training in horticulture, soils, entomology, plant pathology, and herbicide control. He must be interested in continuing to learn and study. He usually holds a B.S. or M.S. degree. The salary range is from $7,000 to $12,000.

Propagator

A nursery propagator is responsible to the nursery superintendent or the nurseryman. He starts new plants from seeds, cuttings, grafting, or other means. He may have several foreman and/or a number of workers in his charge. He must know the cultural techniques of propagating hundreds of kinds of woody and herbaceous plants; know how to operate greenhouses, hotbeds, and outdoor seed beds; and have a thorough knowledge of insect and disease control. He must also plan propagation schedules and be able to identify plants readily.

He has usually had training and experience beyond the high school level. Some nursery propagators have college degrees.

The annual salary range is from $6,000 to $12,000.

Nursery Production Manager

A nursery production manager is in charge of producing the plant material. He is directly responsible to the nursery superintendent (or if there is none, the nurseryman). He must know cultural techniques, equipment use and maintenance, and personnel management. He must have a detailed knowledge of ornamental woody plants and their growth requirements. He plans schedules for propagation, planting, transplanting, and harvesting crops of trees, shrubs, vines, ground covers and possibly roses and perennial flowers. He must know how to achieve quality control. With his foremen, he plans work schedules.

The nursery production manager has usually had several years of training beyond high school, together with several years of practical experience.

He may have a salary ranging from about $5,000 to $10,000 depending on the extent of his responsibility.

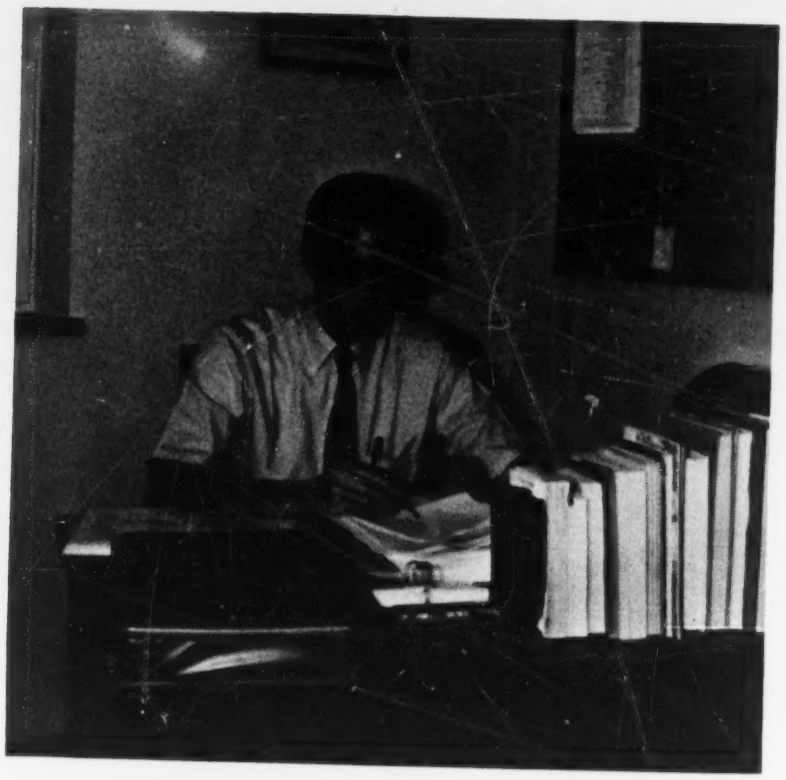
Nursery Superintendent

In a large operation a nursery superintendent has responsibilities delegated to him by the nurseryman. In a small nursery the responsibilities of the nursery superintendent are usually handled by the nurseryman. He has general supervision of the production manager, propagator, nursery technician, storage manager, sales manager, and physical plant manager (if there is one). He acts as a coordinator among all these so that the nursery accomplishes its objective of producing and selling nursery plants profitably.

He usually has had several years of training and experience beyond high school. He must know business management thoroughly.

His salary may range from $6,000 to $18,000 depending on the extent of his responsibility.

Nurseryman



A nurseryman usually is also the owner and manager of the business. In a large, incorporated nursery firm, he is directly responsible to the board of directors (who are elected by the stockholders). He makes major decisions in regard to financing, stock control, work schedules, purchases, sales, hiring and training of employees, maintenance of facilities and equipment, and expansion. It is his duty to determine policy. He must make long-range and short-range plans of the work to be done, assign the work to the appropriate positions within the company, make sure it is properly done, and evaluate the results. He frequently seeks advice and suggestions from other nurserymen and experts, as well as from employees within the company. In a small nursery business, he may have all the managerial duties of all positions down to the foreman level. In a large firm, stockholders determine policy and make major decisions, while the nurseryman carries them out.

A nurseryman must not only know plant material and cultural techniques, but also the business management aspects of a nursery. He has usually had several years of training beyond the high school level. Many are college graduates. He has usually also had a number of years of practical experience. His salary may range from $6,000 to $20,000 or more depending on the extent of his responsibility.

Nursery Organization

In a large wholesale nursery the personnel would be organized as indicated in Figure 6. The lines between blocks indicate lines of responsibility. In a smaller wholesale nursery, many of the positions would be combined as shown in Figure 7. A landscape-nursery might be organized as indicated in Figure 8.

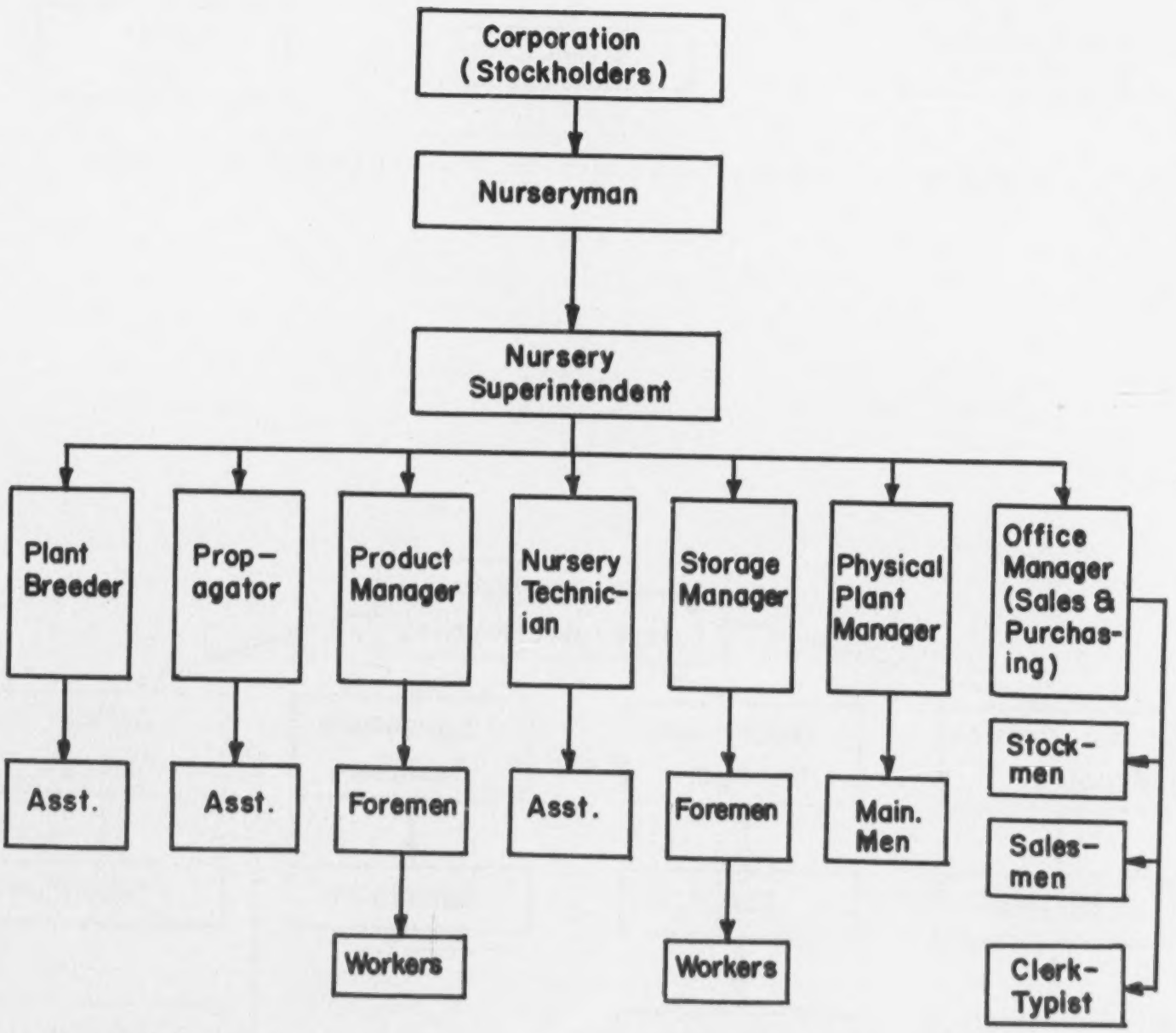


Figure 6. Organization chart for a large wholesale nursery.

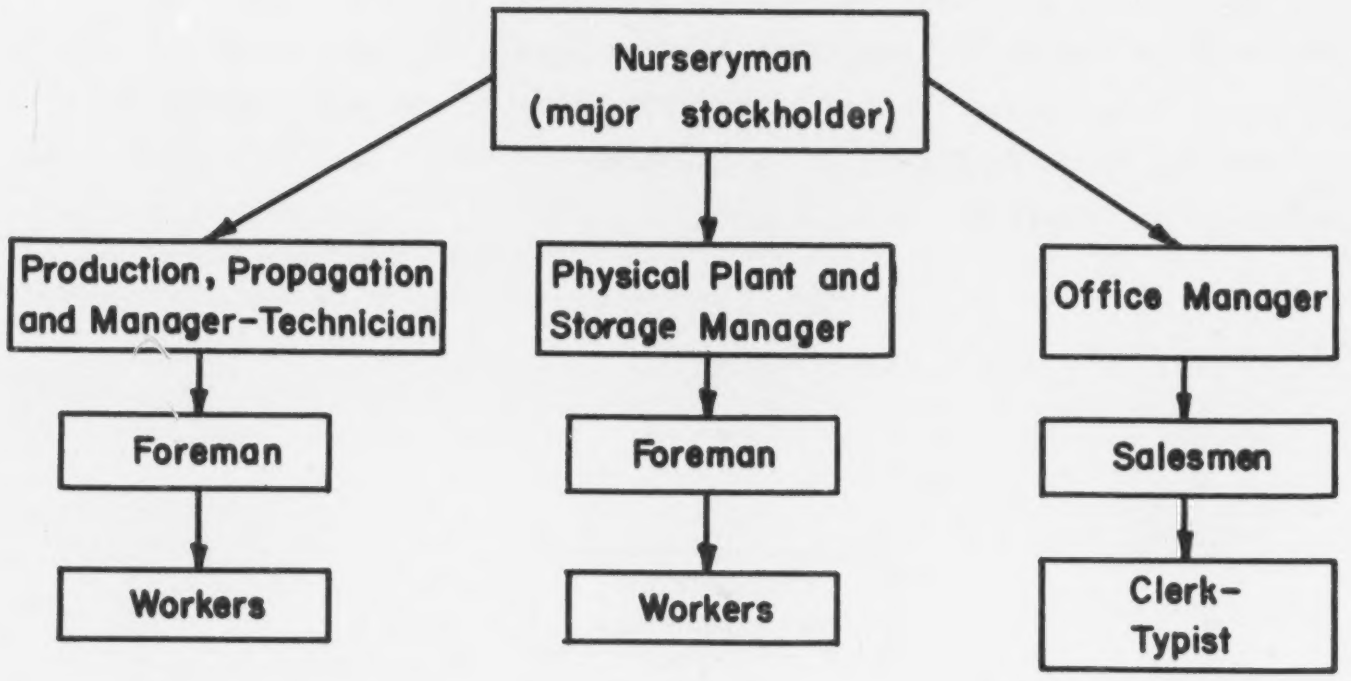


Figure 7. Organization chart for a small wholesale nursery.

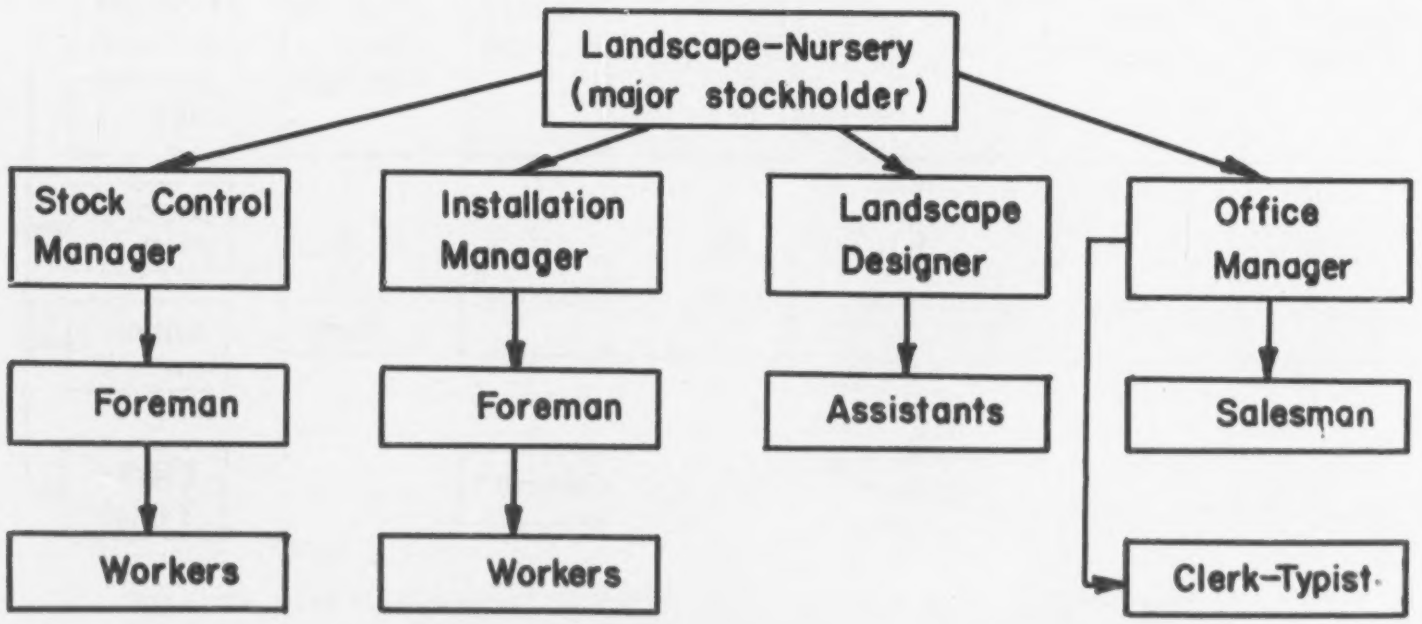


Figure 8. Organization chart for a landscape nursery.

Related Occupations

Some additional occupations that are closely related to Nursery Production include:

Landscape Architect
Landscape Designer
Landscape Contractor
Garden Center Salesman
Nursery Broker
Nursery Inspector
Teacher of Ornamental Horticulture
Research in Ornamental Horticulture

Additional Information

The following information about employment opportunities and numbers of nurseries in Northeastern States is derived from Reference 40, Scope of the Nursery Industry, 1968. Horticultural Research Institute, Washington, D.C.

In 1968, U.S. wholesale nursery production firms employed persons in the catagories listed below, and estimated the number of additional (new) employees they needed as indicated.

	1968 Nursery Personnel	Additional Personnel Needed
Supervisory	5,700	1,700
Landscape Designers	150	500
Clerical and Office Workers	1,850	380
Propagators and Growers	1,550	600
Salesmen	1,700	1,500
Skilled Workers	10,000	5,000

The numbers of nurseries in the leading nursery production states of Northeast U.S. as given in table 4, were derived from U.S. Census of Agriculture: 1959. Volume V, Special Reports, Part I. - Horticultural Specialties, U.S. Bureau of Census, U.S. Government Printing Office, Washington, D.C. 1962., Reference 49.

Table 4 . Numbers of nurseries in northeast United States in 1958.

State	Nurseries
Pennsylvania	409
Ohio	408
New York	387
New Jersey	329
Michigan	327
Illinois	251
Indiana	162
North Carolina	158
Connecticut	148
Massachussetts	137
Virginia	116
Maryland	112
Wisconsin	100
West Virginia	45
Delaware	23

Additional states that reported large numbers of nurseries included Oregon, with 237, Texas, 424, Florida, 684, and California with 712.

Although there are no recent figures or numbers of nurseries in each state, Reference 40, Scope of the Nursery Industry 1968, gives a national total of 5,500, a decrease from 6,757 in 1959.

The national trend is toward fewer, but larger nurseries, doing a larger volume of business, with an urgent need for more employees who are better skilled.

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Suggested Learning Activities

1. Have the class participate in a survey of occupational opportunities in nursery businesses which exist in the local community. The purpose is to identify career opportunities and to make employers in the nursery business aware of potential employees.
2. Visit a local nursery at a time when the nurseryman can explain how it operates.
3. Invite the school guidance counselor to explore careers in nursery production with a group of 8th or 9th grade students visiting the Vocational Agricultural Department.

4. Have the class interview persons employed by commercial nurseries to get information about career opportunities and requirements in nursery production.
5. Review with the class the importance of developing good working relationships with fellow employees, supervisors, and customers.
6. Ask each student to write a brief paper indicating which of the positions discussed interests him most and a statement of why it does. Ask him to list the qualifications for this position that he already has. Have him make another list of the qualifications he must develop. For each of the latter have him write a statement of how he can develop them.

Test

1. What are the duties of a nurseryman?
2. Who is the owner and manager of a nursery business?
3. Who coordinates the work of the production manager, propagator, technician, storage manager, sales manager, and physical plant manager?
4. Who is responsible for producing the plant materials in a nursery?
5. Give at least five duties of a storage manager.
6. Who develops cultivars that are superior in growth rate, pest resistance, new in color, fruit, or form?
7. Who is responsible for making recommendations for fertilizer application and pest and weed control measures?
8. Who is in charge of the repair and maintenance of nursery buildings, grounds, and equipment?
9. What should a nursery foreman know in regard to his work?
10. Who is responsible for promoting and selling nursery stock?
11. What should be the educational qualifications of the following people in the nursery business?

    a. nurseryman
    b. superintendent
    c. production manager
    d. propagator
    e. technician
    f. plant breeder
    g. storage manager
    h. physical plant manager
    i. office manager
    j. foreman
    k. stock man
    l. salesman
    m. worker
    n. clerk

CHAPTER 3

The Physical Plant

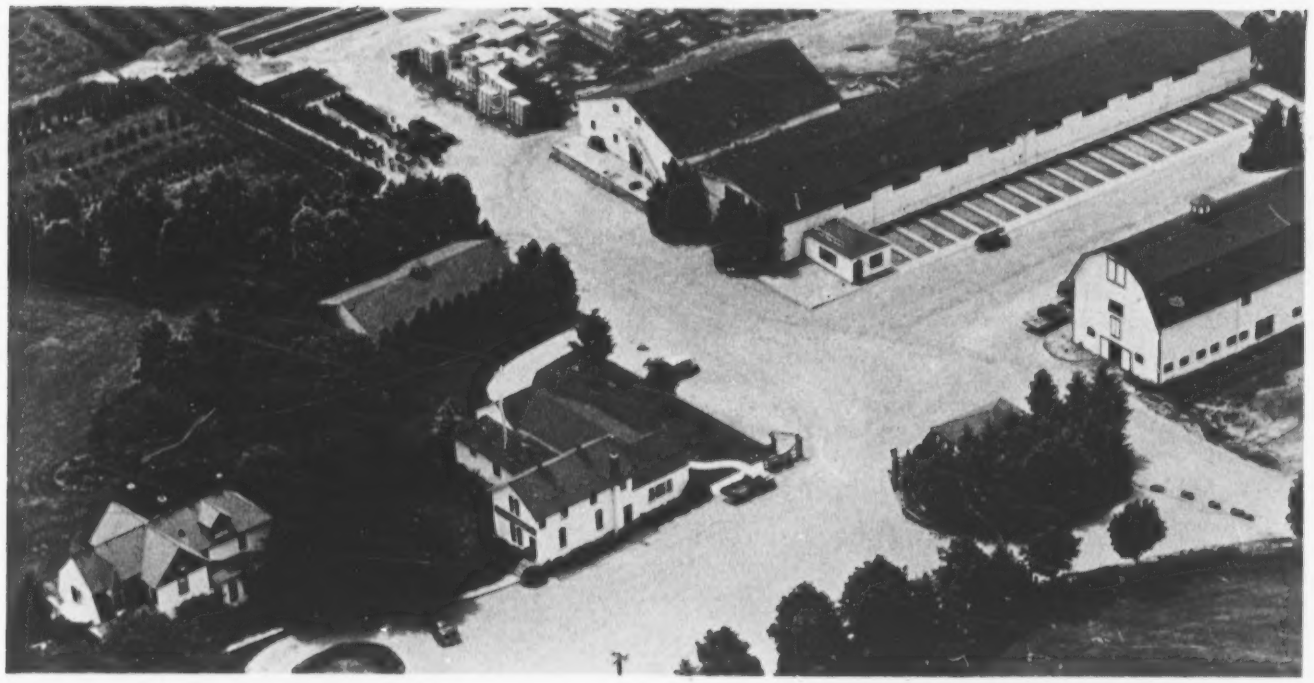

Figure 9. Aerial view of office and other buildings at a large wholesale nursery. (Courtesy D. Hill Nursery Co., Dundee, IL)

Learning Objectives

1. To learn the factors to consider in the selection of a nursery site.
2. To learn how the areas are usually arranged in the layout of a nursery.
3. To learn what facilities and equipment are necessary for the production of nursery plants.

Key Questions

1. What should be considered in choosing a nursery site?
2. What determines the layout of a wholesale nursery?
3. Why are relatively small greenhouses used for propagation?
4. What type of soil is best for evergreens? For deciduous shrubs? Why?
5. What determines the amount of space between rows of plants in field grown stock?
6. What are the most important tools and equipment used for nursery stock?
7. What are the advantages of using containers for growing plants? What are the disadvantages?
8. What type of medium is used for propagating cuttings, seeds, and seedlings?

Key Words

Asexual propagation - the production of new plants from shoot, stem, leaf, or root pieces

Deciduous trees - trees whose leaves fall off in autumn

Drainage - the removal of water from soil due to the pull of gravity or air drainage - the movement of air downhill

Evergreen trees - trees with leaves that are green throughout the year

Greenhouse - a transparent structu e in which plants may be propagated and grown under controlled temperature, moisture, nutrition, and light conditions

Green manure - crops grown and plowed under to add organic matter and nutrients to the soil

Heeling-in - temporarily placing newly dug stock in a trench, with roots covered with moist soil, peat, or shingletow

Herbaceous perennials - non-woody flowering plants that live for 2 or more years

Herbicide - a chemical for destroying undesirable plants

Insecticide - a chemical for destroying harmful insects

Mulching materials - leaves, straws, and other materials spread on the ground to reduce evaporation of water from the soil surface

Pruning tools - shears, saws, or knives for removal of parts of a plant to increase fruit or flower production, or to improve the form

Retailer - a merchant who sells goods in small quantities direct to the consumer

Sexual propagation - the production of new plants from seeds

Soil map - drawing of a land area showing the types of soils

Soil profile - a cross section of the soil

Stock - a supply for sale

Topography - the surface features of a piece of land

Wholesaler - one who sells stock in large quantities to the retailer

The Physical Plant

The physical plant of a nursery, includes the land, buildings, machinery, tools, and expendable materials that are used in the operation of the business. If you were to make a study of the physical plants of a dozen wholesale nurseries, you would find that they have a number of things in common. For example, each is generally located within a convenient distance of its marketing areas. Each has a similar arrangement of greenhouses, storage buildings, access roads, and fields. The buildings may even be similar in appearance because they serve similar needs. While there may be variations in equipment and supplies to suit the particular needs of one nursery, to a large extent the tractors, cultivators, sprayers, irrigation systems, and so forth, are similar.

The idea of growing nursery stock in containers originated in California, and is being gradually adopted by nurseries all over the United States. This new way of growing nursery stock is having an effect on the physical plants. You may find nurseries in many different stages of incorporating this technique into their operations.

This section is concerned with: (1) nursery site selection, (2) nursery arrangement and layout, (3) facilities, (4) equipment, and (5) supplies.

Nursery Site Selection

As you study nurseries, you may wonder why they are located where they are. The person who started the nursery considered a number of things in choosing a particular site. He had to consider the marketing area he planned to serve. He had to choose a climatic zone suitable for nursery stock. The topography has an influence on how well the plants will grow. The kind of soil and the availability of water are also important. He also had to compare the relative costs of operating the business in alternative locations.

A wholesale nursery usually serves an area within about 500 miles of the nursery. The cost of shipping plant material becomes uneconomical at greater distances than this. In the Northeastern United States there is a concentration of nurseries in New Jersey, Eastern Pennsylvania, and lower New England.

There is another concentration of them in Western Pennsylvania, Western New York, and Eastern Ohio. These 2 areas of concentration serve large urban areas with radii of 500 miles. Mail order nurseries serve the entire United States. Some large wholesale nurseries in Western and Southern States ship bare-root stock in large quantities to Eastern and Northern markets. They have the cost advantage of producing certain plants in a short time because of a longer growing season. This lower production cost permits competitive pricing with stock produced close to distant markets in spite of greater shipping cost. A retail nursery or a garden store generally serves an area within a radius of less than 100 miles.

Young nursery plants may be killed in large numbers if grown where the temperatures drop suddenly in winter or are excessively hot in summer. Large bodies of water have a moderating influence on the climate, causing air temperatures to change more slowly within areas from 30 to 50 miles of the water. For this reason, nurseries in Northeastern U.S. tend to be close to such large bodies of water as Lake Erie, Lake Ontario, Delaware Bay, Long Island Sound, and the Atlantic Ocean. The Plant Hardiness Zone Map, Figure 10, illustrates the influence of these bodies of water. Plants which are hardy in Zone 5, are also hardy in Zones 6,7, and 8, but are winter-killed in Zones 3 and 4. If you wish to examine a more detailed map, see Reference 33. Plant Hardiness Zone Map.

Nurseries are generally located on gently rolling land, or land with a slight slope, rather than low flat land. While flat land would be ideal from the standpoint of operating machinery, there are more important considerations. Low, flat land has poor air drainage, and the accumulation of stagnant, highly humid air favors the development of airborn plant diseases. Cold air accumulates in such areas in fall and spring, so that early and late frosts occur more frequently there than on higher ground. Low flat land may also be subject to flooding. High hills, on the other hand, present other problems, they are usually windswept and dry, a poor place for growing young plants. Gently rolling hills provide a good compromise in having good air drainage and low wind velocities. Machinery can be easily operated on them.

Young plants need adequate water, evenly supplied throughout the growing season. Most areas of Northeastern United States have natural rainfall that generally supplies this need of field-grown stock, so extensive irrigation systems are not needed. Adequate supplies of good water are

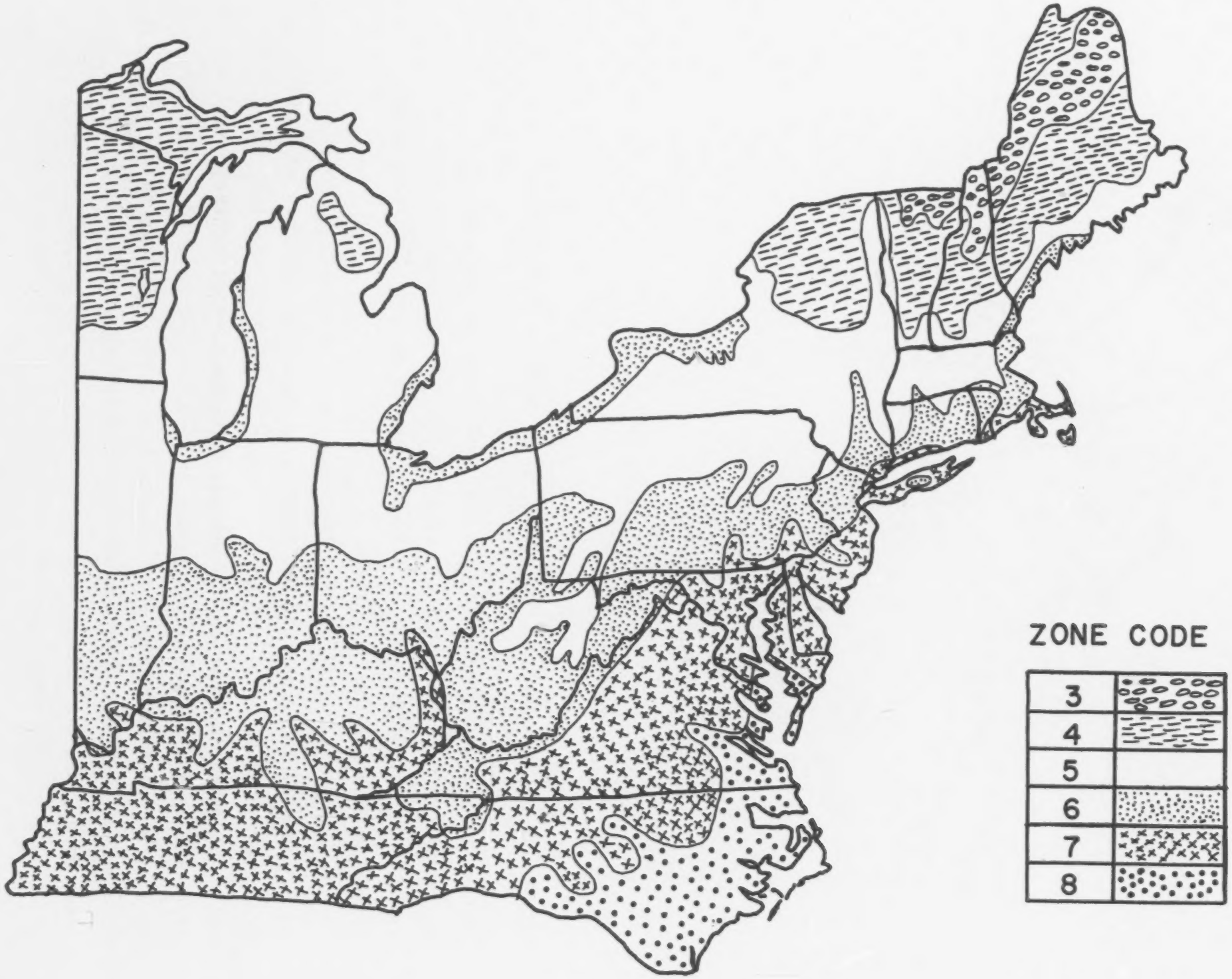

Figure 10. Plant Hardiness Zone Map for Certain Northeastern States *

* Adapted from Plant Hardiness Zone Map, Agricultural Research Service, United States Department of Agriculture, Miscellaneous Publication No. 814.

Figure 11. Annual rainfall distribution in Northeastern States.

needed for propagation greenhouses and coldframes, as well as for container-grown stock. Hail can cause considerable damage to nursery plants. Fortunately, heavy hail usually occurs in very localized areas, and these areas can be avoided.

Another factor that governs the location of a nursery is the kind of soil needed for producing the plants. Plants that are sold bare-root, (that is, without soil), are grown in sandy soil. Well drained, sandy soil that contains some organic matter, and that is appropriately fertilized, will produce rapid growth if rainfall has been adequate. It is also much easier to dig these plants in a sandy soil than in a heavier soil. Plants that are sold B&B (balled and burlapped) on the other hand, must be grown in a loam or clay-loam soil so that when the plants are dug the soil ball will hold together. A broken soil ball

means damaged roots, and possible death of the plant. Certain nursery plants can be moved most successfully as B&B or container-grown plants. Special soil mixtures are used for container-grown stock, and an adequate source of good soil must be available for producing plants in this way. The only requirement for the surface on which container stock is grown is that it must drain well. Sometimes nurseries have to acquire land in two or more locations in order to satisfy the soil needs of different kinds of plants.

The cost of operating a nursery in one location may be more than in another location. This operating cost is usually referred to as "overhead." One overhead item is taxes. Nurseries are generally located within 15 to 30 miles from large cities in order to avoid high tax rates. This also gives them greater flexibility in expanding the size of the operation in the same location if this becomes desirable. The availability of such utilities as water, electricity, and fuel must also be considered. A location close to major highways is also important, because most wholesale nurseries ship their products by truck. Workers from small towns are generally reliable and responsible and are likely to stay with a company. These people will also be likely to work for slightly less money than workers from other areas. For this reason, nurseries tend to be located in the vicinity of small towns. However, at peak periods, nurseries have to hire seasonal workers, and some way must be arranged to obtain their services.

Another factor that influences the location of a nursery has only been understood during recent years. Air pollutants from certain kinds of manufacturing processes have been found to damage plants as much as 50 miles downwind (prevailing wind) from the industrial plant. For safety from plant damage, then, a nursery should not be located on the downwind side of an industrial area.

Nursery Arrangement and Layout

Once the site for the nursery has been chosen, the arrangement of the buildings and growing areas must be planned. Wholesale nurseries vary

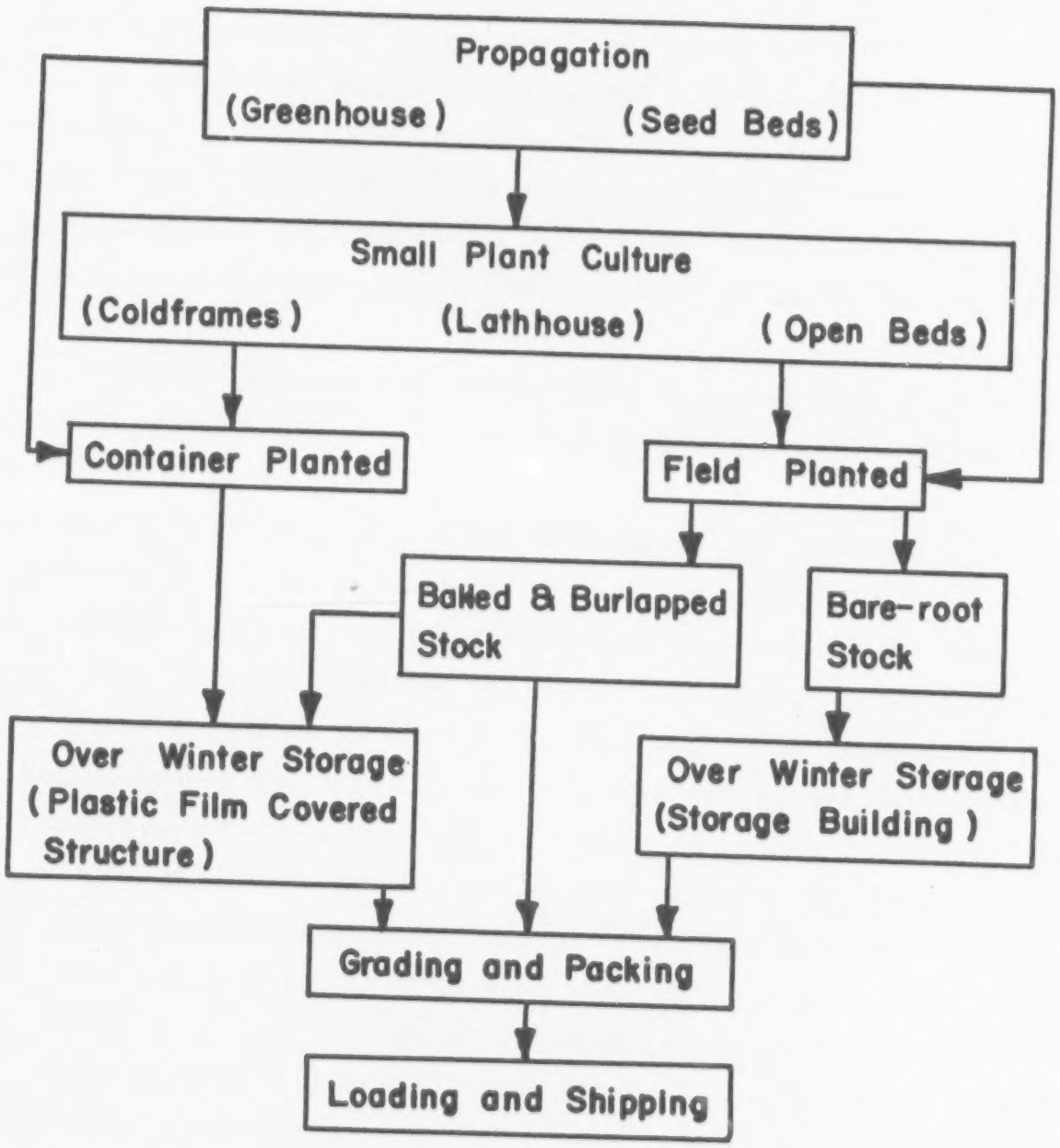

Figure 12. Flow chart of nursery crop production.

from 70 to 700 or more acres in size. A few cover 2000 acres. The average wholesale nursery has about 135 acres and employs 17 people full time, and about 17 more during peak work load periods.

The buildings and growing areas in a nursery are usually arranged in a kind of assembly line based on the steps involved from the propagation of the plants to the shipping of them. Figure 12, "Flow chart of nursery crop production," shows the steps that are involved in this process. If you compare this chart with Figure 13, "A wholesale nursery layout," and trace the movement of the plant material from the

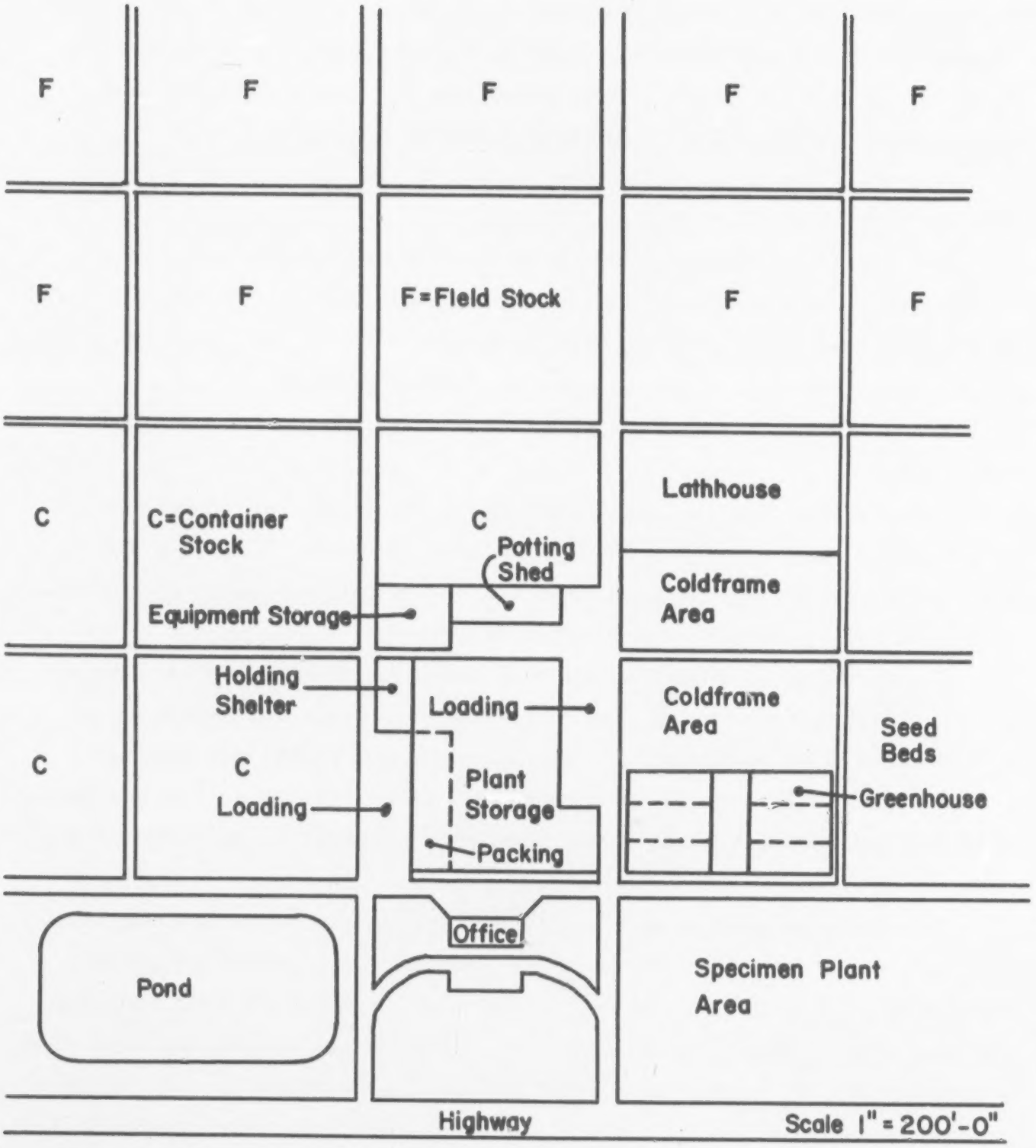

Figure 13. A wholesale nursery layout.

greenhouse or seed bed through the steps to shipping, it may be seen that the parts of a nursery are usually arranged to allow a convenient movement of the plant material. Additional arrangements of functional areas may be seen on pages 4-6 in Reference 41, "Site Selection and Development," Section III, Nursery Management Handbook.

Figure 13 illustrates how the buildings and features of a wholesale nursery might be arranged in a layout.

The office is generally close to the highway for the convenience of customers and employees, and for efficiency. Often a portion of the grounds near the office is planted with specimens of the kinds of plants grown by the nursery. This enables the nursery personnel to observe the performance of the plants, and allows customers to examine mature specimens.

The storage, packing, and handling of the plants are usually done in one large building which also has a loading area. The illustration also shows the container stock area nearby so that a minimum of handling is needed for loading container-grown plants.

The propagation greenhouses, seed beds, lathhouse, and coldframes are generally located close to the storage buildings for convenience. A "headhouse," or workroom, is usually connected to the greenhouses.

A river or a pond may be a source of water for irrigation purposes, although some nurseries buy water from public utilities at commercial rates.

Although the arrangement of field planting blocks varies considerably from one nursery to another, many are laid out with "dirt" or gravel roads forming the boundaries for square blocks about 300 feet long and 300 feet wide. These blocks are often lined on the prevailing wind side with deciduous or evergreen trees that serve as windbreaks for the protection of young plants. Partially healed grafts are very susceptible to wind breakage. These windbreaks also provide protection from drying winds that may damage broadleaved evergreens in winter. These blocks are often planted with groups of plants that require the same length of time to reach maturity. For example, one block might be planted to

standard deciduous trees; another to medium height deciduous shrubs; another to spreading junipers; and another to rhododendrons only. This is done so a block can be completely cleared at one time, planted with a cover crop over winter and replanted the following spring. In many instances a cover crop remains on a field for 1 or 2 full years in order to get maximum replacement of organic matter. These blocks are usually arranged in some kind of coded system using number or letter designations so that plants may be easily and quickly located and identified. Table 8, page 111, in the unit on field grown stock gives the spacing and years required by groups of nursery plants while growing in the field.

The sizes of the buildings, structures, and growing areas are determined by the capacity requirements for the volume of plant material produced by the nursery. Considerable experience and study are needed to determine appropriate sizes. Needless to say, almost every nursery is engaged in a continuous evaluation of new and better ways to do things. This study leads to changes in or additions to the physical plant.

Facilities

The facilities in a wholesale nursery include structures for the propagation of plants, for growing small plants, equipment and supply storage buildings, plant storage buildings, a grading room, a holding shelter, a loading dock, and an office building. As indicated earlier, these facilities are usually arranged in a pattern that goes with the various steps the plants go through from propagation to shipping.

Figure 14. A sashhouse.

The propagation facilities in a nursery usually include a greenhouse, seed beds, and coldframes.

The propagation greenhouse often consists of several to many "sashhouses" as illustrated in Figure 14. A sashhouse is made

up of units of standard 3 feet by 6 feet frames which are glazed with glass. These frames, or sashes, may be easily lifted for ventilation, or removed completely if desired. Since it is easier to maintain the high humidity required for propagation in small greenhouses rather than large ones, the sashhouse is very useful for nursery propagation. Some nurseries use wood frame or metal frame greenhouses which are about twice the size of a sashhouse, and contain 2 aisles and 3 benches instead of only 1 aisle and 2 benches. These propagation houses are equipped with a mist system, as shown in Figure 43, page 73, which is automatically operated to maintain a high relative humidity for cuttings during the rooting period, or for grafts during the healing period. This mist system also helps keep the rooting medium moist. The benches are arranged at a convenient working height and contain about 6 inches of sand, peat, perlite, or some other rooting medium. This rooting medium is warmed to a temperature above that of the air by means of heat lines under the benches and a skirt along the edge of the benches to enclose warm air under the bench. This method of heating is referred to as "bottom heat." Electric heating cables are sometimes installed in the bottom of the benches, as a substitute for heat pipes for the same purpose. A thermostatic control maintains even air temperatures within the greenhouse. These greenhouses may also be used for starting seeds, but seeds of woody plants are usually started into growth in outdoor seed beds. The greenhouses are attached to a building called a "headhouse", which contains the heating plant, equipment, and supply storage for the greenhouse, and work space.

Outdoor seed beds for starting woody plants may be from 3 to 4 feet in width. Fine seeds may be sown in rows only a few inches apart in these beds. Figure 15, page 45, illustrates one of these seed beds.

Shading is needed for plants raised from seed. Many propagators use lath frames 4 feet by 6 feet for shading. These frames are placed directly on the mulched seedbed until germination begins and are then raised on stakes above the beds. Larger seeds may be sown in rows that are 6 to 8 inches apart, while very large seeds, such as those of walnuts and peaches may be sown directly in the nursery row at the distance at which the plants will be grown until they are dug and sold. Because seedling plants have

Figure 15. Nursery seed bed.

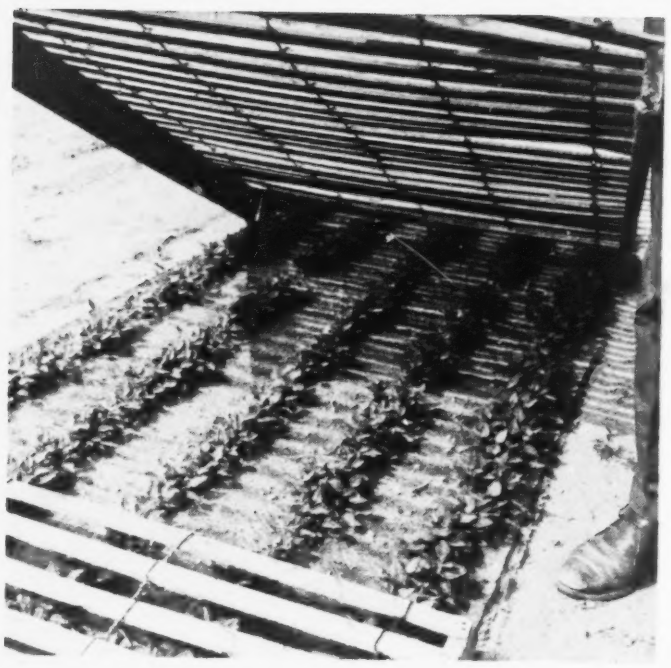

Figure 16. One-year-old seedlings in seed bed.

shallow root systems that may not get adequate moisture during dry periods, the outdoor seed bed areas are equipped with irrigation systems so that the plants may be watered when necessary. Some slow-growing woody plants may remain in the seed beds for 2 or 3 years before they are large enough to be moved into the field or into containers.

Figure 17. A cold frame.

After the plants have been propagated they are usually grown in special facilities until they are large enough to be planted in the field or in containers Cold frames, transplant beds, and lathhouses are used for this purpose.

Figure 17 shows a cold frame used for nursery plants. After the cuttings have formed roots, or grafts are well "knitted" in the greenhouse, the plants are planted in small containers and are placed in a cold frame. The

purpose of the cold frame is to provide winter protection for the small plants at the end of the first growing season. In late fall the cold frames are covered with sash, and straw may be placed along the outside of the wall of the frame to keep temperatures from dropping too rapidly and injuring the plants. In very cold weather, straw mats, or other material is placed over the glass to give added protection. Nursery cold frames are built about 12 feet wide and about 50 feet long. A double row of standard cold frame sash is used for covering the cold frame. A hotbed simply a cold frame with bottom heat and an appropriate medium for propagation purposes. Hotbeds are difficult to work in, and controlling the relative humidity and temperature in them is often nearly impossible;--for this reason greenhouses have almost entirely replaced them for propagation purposes. A heated frame is one which has some kind of provision for heating the air in the frame; they are used more frequently by greenhouse crop producers than by nurserymen.

Outdoor beds, similar to seed beds, are often used for carrying slow growing or tender plants for a year or two after they have been wintered in a cold frame. The small plants are planted into the beds at a 6 by 6 or 8 by 8-inch spacing. The beds are usually covered with snow fencing to reduce the light intensity, to help maintain a constant temperature, and to prevent rapid water loss by evaporation. The wooden strips should run north and south to provide each plant with alternate exposure to sun and shade.

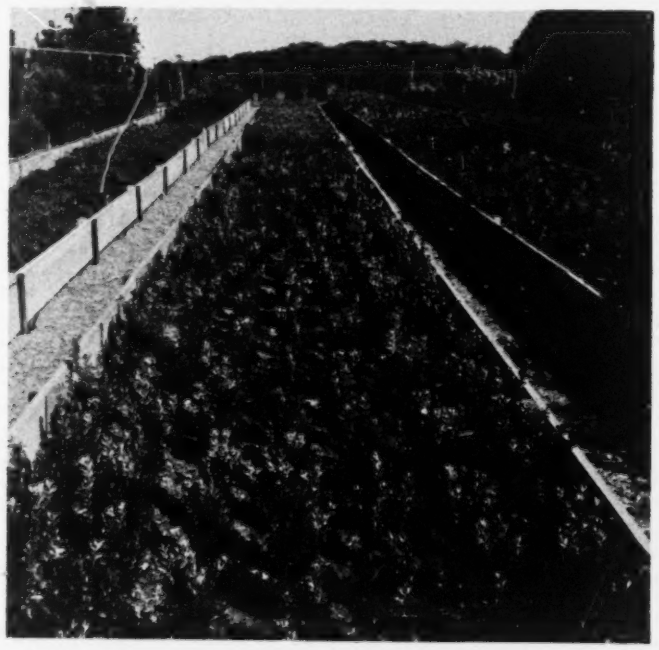

Figure 18. Bed for small plants.

A lathhouse serves the same purpose as beds covered with snow fencing, but in this case the snow-fencing, or wood strips arranged with the same spacing, is supported on a framework 7 to 8 feet above the ground. This makes working with the plants more convenient. Beds about 4 to 6 feet wide are usually laid out in the lathhouse, with walkways about 2 feet wide between them. The sides of the beds usually consist of 6-inch wooden boards set on edge. Lathhouses, as well as beds, are provided with irrigation

Figure 19. A lathhouse.

systems that can be used to assure that the plants have adequate moisture at all times. Woven plastic fabric is sometimes used in place of the lath. Several different weaves are available that provide different percentages of light reduction. A nursery lathhouse is shown in Figure 19.

Container nursery stock is often grown in beds under a framework that has no covering during the spring, summer, and autumn. Winter protection is provided by

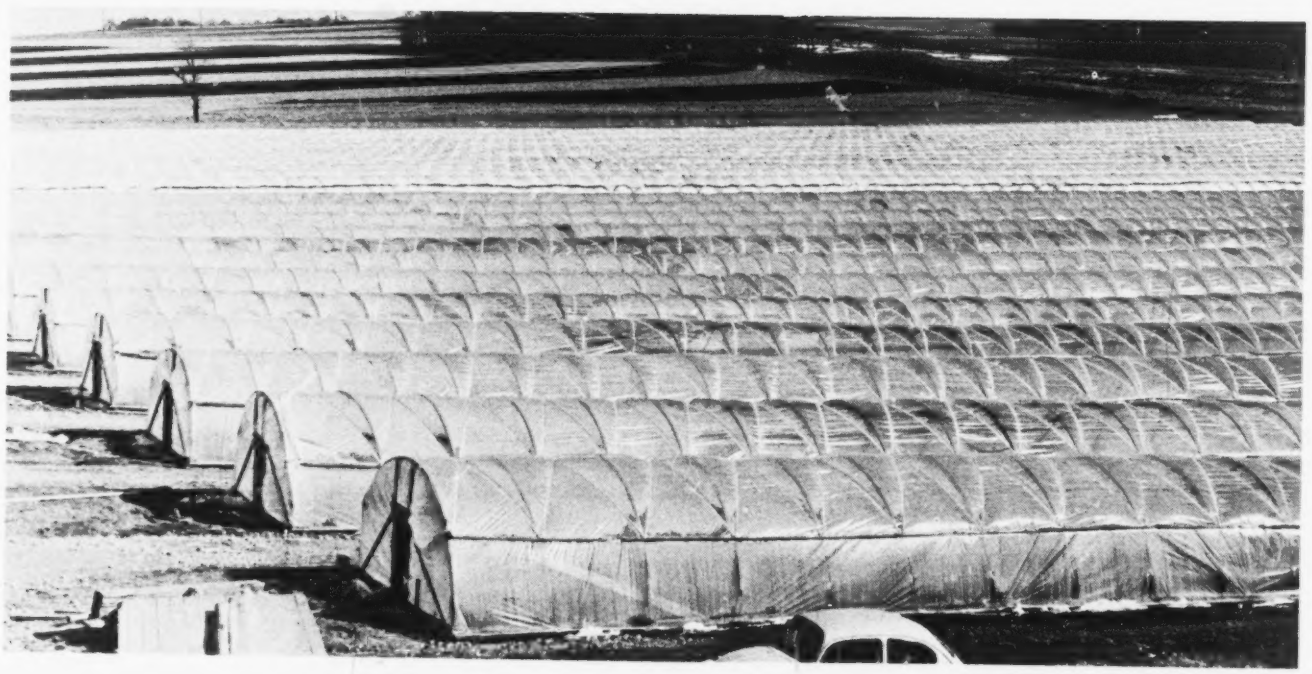

Figure 20. Wintering houses for container nursery stock. (Courtesy Conard-Pyle Co., West Grove, PA)

sheets of polyethylene film that are placed tightly over the framework in late fall. This covering prevents sudden changes in temperature that would harm the plants, and also protects them from drying winter winds. Figure 20 illustrates two kinds of structures used for this purpose. Some nurseries have extensive land areas covered in this manner.

A wholesale nursery requires a number of storage and service buildings and facilities.

The single largest building needed is a "common" cold storage building for holding bare root nursery stock. This kind of stock is dug in dormant condition in the fall and is placed in storage directly from the field. During the winter months it is graded and returned to the cold storage to await the appropriate time for packing and shipping in the spring. These buildings ("common" storage) are usually cooled "naturally," that is, by opening them in cold weather in the fall to lower the temperature, and closing them on warm days to retain the cold air. They are usually maintained at temperatures of 35 to 40°F, and are well insulated to prevent fluctuations in temperature. To prevent the stock in them from losing moisture, a high relative humidity is maintained at all times. Many such storage buildings include one or several cold storage rooms that are artificially cooled for holding nursery stock that requires very precise, even temperature control. Roses, for example are usually stored in such a room at a temperature of 34°F, and a relative humidity of 95 to 98 percent, because they have a very "shallow" dormancy. Rose plants require only a few weeks of low temperature, and thereafter they begin to grow very quickly at only slightly higher temperatures than the storage temperature.

A grading and packing room, with tables for pruning, grading, labeling, bundling, and packing the plants is usually connected to, or is part of the "common" storage building. Low temperatures and high relative humidity must be kept in this room in order to keep the plants moist and dormant.

Storage buildings are needed for the heavy equipment used in field work. Trucks, tractors, sprayers, fork lifts, and special digging machinery require shelter from the weather. A work area for repair and maintenance of this equipment is usually included.

Additional storage is needed for such supplies as fertilizer, soil amendments, spray materials, burlap, twine, pots, etc.

A holding shelter, with a roof similar to that of a lathhouse to provide a sunshade, and a sprinkling system to prevent drying of the plants awaiting shipment is usually constructed at the loading area.

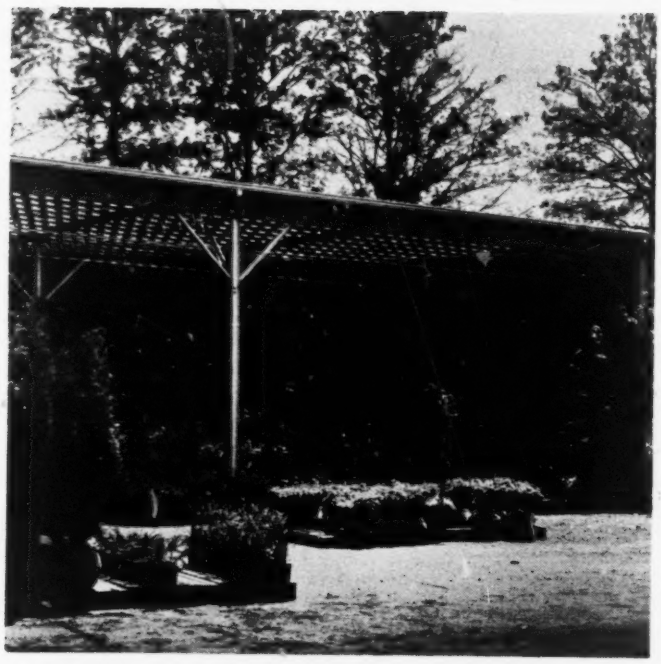

Figure 21 . A holding shelter. (Courtesy Princeton Nurseries, Princeton, NJ)

Balled and burlapped stock as well as container stock may be held in this area for several days, or several weeks if necessary, to await the assembly of all the plant material to fill a particular order.

The loading area is usually a large paved area of sufficient size for the maneuvering of trucks and handling of boxes of packed bare-root plant material, as well as balled and burlapped stock, and container stock. Some nurseries have loading docks so that the materials may be moved directly into the truck beds without high lifting. Other nurseries use fork lifts for loading trucks. Some nurseries have loading areas that are covered with a roof so that the loading operations can be conducted under shelter.

An office area or building is necessary for housing the inventory, purchase, sales, payroll, and other records, as well as the personnel and specialized equipment for maintaining these records. The nurseryman, business manager, and other managers also have offices in this area. Space for 3 or 4 to 18 or 20 people, together with the necessary files and equipment, may be required in this facility, depending upon the size of the nursery.

Roads in the vicinity of the buildings are usually paved with asphalt to reduce the dust nuisance, and are generally made about 25 feet wide so that trucks and heavy equipment may pass easily. Access roads in the fields are usually gravel roads, and are generally about 10 to 12 feet wide.

Large Equipment

Probably the single most important item of large equipment in a nursery is the tractor. A detailed discussion of tractors is given on

pages 134 to 176 in Reference 14. Farm Power and Machinery Management. Tractor attachments that are commonly used in nurseries are: plows, harrows, cultivators, planters, root pruners, plant diggers, scoops, spreaders, mowers, sprayers, and dusters. Trucks, wagons, and fork lifts are also used. Tillage equipment and its use is explained in detail in Reference 14. Farm Power and Machinery Management, pages 28-35. Irrigation systems, both portable and stationary, are also important.

Figure 22. A utility tractor.

Tractors of several sizes are used by wholesale nurseries. The medium size utility tractor, in the 30 to 40 hp range, is probably used more than others. Models equipped with hydraulic systems are usually chosen because of the specialized power equipment used in the nursery. Some nurseries have a medium size crawler-type tractor especially for digging plants when the soil is very wet, because it has better traction than one with wheels, and because there is less soil compaction when it is used on wet soil. Where the amount of work for it can justify the cost, special tractors with high clearance are used for cultivating and spraying plantings of stock that are 3 to 6 feet high. Heavy duty tractors in the 60 to 100 hp range and equipped with power take off are used in large nurseries for the preparation of large areas for green manure or cover crops, and in fitting the soil for planting of large areas of nursery stock. Small tractors in the 15 to 20 hp range are often used for cultivating between the rows of stock and for other jobs in which maneuverability is important and great power is not required. Tractors that are hinged in the middle (articulated) and equipped with hydraulic systems sometimes are used with large tree diggers. In small nurseries power tillers are often used for cultivation.

Figure 23. A two-way moldboard plow attachment.

Two types of moldboard plows are used in nurseries. The one-way plow is used on relatively flat land. The two-way moldboard plow is equipped with two sets of bottoms, one that turns the soil to the right, and another that turns the soil to the left. They may be quickly interchanged at the end of each pass across a sloping field, a situation in which the soil should always be turned uphill. Chisel plows offer the advantage of mixing crop residues into the soil rather than putting them in a layer under the soil. The disc harrow is commonly used in nurseries for breaking up the large lumps of soil and the uneven surface that are left after field has been plowed. Green manure crops, winter cover crops, and rowed nursery stock are usually planted directly in soil that has been prepared by discing. Spring tooth harrows and spike tooth harrows are seldom used in nurseries.

Figure 24. A power tiller.

The rotary hoe attachment may be used in place of the disc harrow for leveling the soil after plowing. It is also a very useful tool for cultivating the soil for weed control. Use of the rotary hoe is explained more fully on pages 38 and 39 in Reference 14, Farm Power and Machinery Management.

Many different kinds of sprayers are used in wholesale nurseries. The spray-boom type is

often used with a high clearance tractor where tall shrubs are growing at too close a spacing to be reached by other means. Orchard sprayers are sometimes used in tree plantings where the space between rows will accommodate them. Large sprayers mounted on small turcks, together with one to several spray lines with nozzles, may be used for the application of pest control materials. The calibration of spreaders, seeders, and sprayers is given on pages 42 to 70 in Reference 14, Farm Power and Machinery Management.

Field application of fertilizer is usually done with the hopper type of spreader commonly used for field crops. This type of spreader may also be used for applications of granular herbicides on the soil surface. Fertilizer solutions are applied in the irrigation water for container stock. This is done by means of special fertilizer injectors. The use of these injectors is discussed in detail in Chapter 7 on container nursery stock, page 158.

Wholesale nurseries often use tractor-drawn planting machines for planting liners in the field. These machines are usually modified celery, cabbage, or tobacco planters that are used for planting two rows at a time. One such machine opens a furrow, places the plant at the correct depth, closes the furrow, and firms the soil. Two men "feed" plants into this machine, one man for each row being planted.

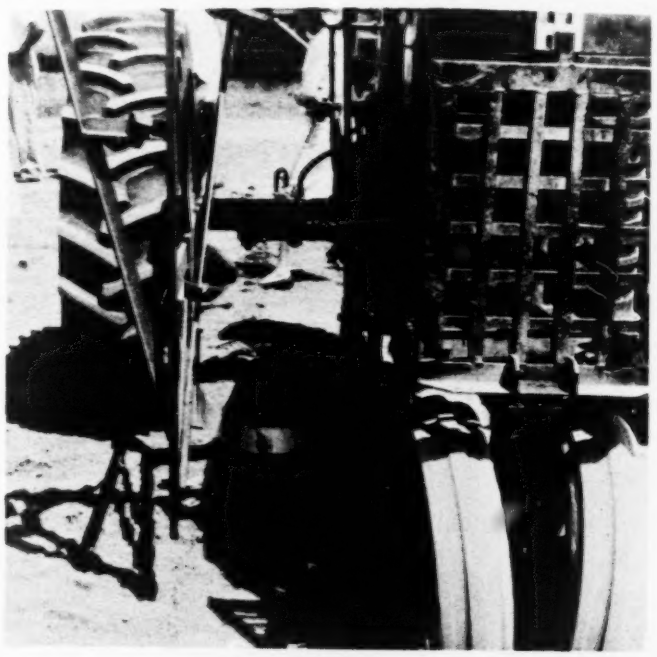

Figure 25. A root pruner for nursery stock.

Root pruning of nursery stock is done to obtain a compact root system, which makes digging, handling, and planting easier and more successful. Root pruners are U-shaped metal straps that are from 12 to 18 inches wide and 18 to 24 inches high. The edge to be passed through the soil is sharp. The root pruning is done by passing this strap directly under the row of plants while pulling it through the soil with

a tractor. Large and medium size root pruners are available from manufacturers, but if small ones are needed, nurseries have to make them because they are not available on the market.

Digger attachments for tractors range from very simple ones for small deciduous stock through more complex ones for medium size deciduous stock. Sophisticated machinery for digging evergreens and trees with a soil ball is also used. For digging bare-root small stock, a minor modification of a root pruner serves well. An upward slanting bar is fastened to the trailing edge of the root pruner. This lifts the plants out of the soil as they are dug. Many similar diggers are equipped with a shaking device that loosens the soil from the roots as the plants are dug. Potato diggers, or modifications of them are often used for digging smaller bare-root nursery stock. High-clearance tractors with strap type diggers are used for digging deciduous trees that are to be moved bare-root. Hydraulically operated cylinders or blades are pressed into the soil around evergreens to lift the plant out with a soil ball which is then wrapped with burlap to give a B&B plant. Other fast techniques for digging B&B stock are still in the developmental stages, and few of them are in use. Two different machines are available for digging large trees with a soil ball. One has of four large blades that are thrust into the soil at an angle so that the edges come together under the tree. With the blades held in position, the tree (together with the soil enclosed) is lifted out of the ground. Working on a similar basis another such machine uses 2 quarter spheres which are thrust into the soil to form a hemisphere under the tree. Although each of these machines is capable of doing the work of 10 digging crews in one day, they are very expensive and would have to have continuous use for long periods in order to be sound investments. A number of different models of trench diggers are also being used for digging large B&B nursery stock.

Figure 26. A hydraulically powered B&B digger.

Tractor-drawn dusters similar to those used for other kinds of field crops are used by nurserymen. If very large areas are to be treated, these applications may be made by helicopters or biplanes by companies hired to do this specialized work.

Fork lifts of various capacities are used in nurseries for loading and unloading heavy materials. A supply of wooden pallets is needed for handling materials in this way. Because these fork lifts may be used either outdoors or indoors, they are usually powered either by wet-cell electric batteries or by propane-fueled engines (which give off no toxic fumes).

Figure 27. Nozzle line irrigation for seed beds.

Figure 28. Fork lifts are used in nurseries.

Irrigation of seed bed areas is usually done by means of permanently installed systems. These usually consist of nozzle lines which are rotated by hand or by devices that are powered by water pressure. Such systems are usually laid out by irrigation specialists. Portable irrigation systems are sometimes used for certain special kinds of field grown stock. Irrigation systems for propagation greenhouses are discussed in the unit on propagation. Irrigation systems for container grown stock are discussed in the unit on container grown stock.

Small Equipment

Small machines and hand tools are used extensively in the nursery business.

Garden tillers are often used for the preparation of seed beds and for the cultivation of small soil areas to control weeds.

Steam chests for treating soil may be made of wood or metal. They are made of appropriate size for the scale of the operation. Greenhouse boilers or special portable boilers may be used for supplying the steam.

Cement mixers, such as those used for mixing mortar for bricklaying, are very convenient for mixing the growing mediums for propagation beds and container stock. At least one large nursery has found that a manure spreader does an excellent job of mixing soil, and is the most economical system using readily available equipment. The ease with which it can be moved from one place to another is another advantage.

Machines that fill containers with the growing medium in an assembly

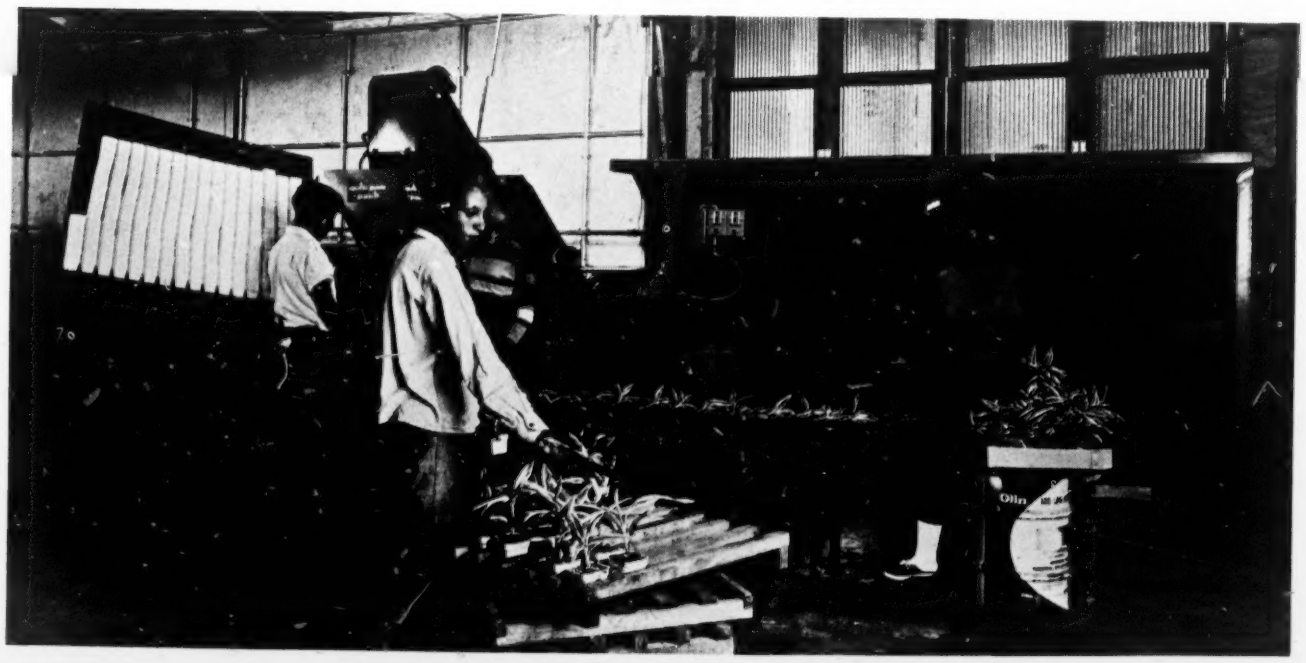

Figure 29. Special machinery to speed potting. (Courtesy Roger Foundry and Machine Co., Kingston, Penna.)

line potting operation are sometimes used. A widely accepted, automatic "potting machine" has not yet been developed, but a number of such machines have been devised and are in use. Some of the labor-saving machinery that is often used at steps along the potting line are: power scoops, soil shredder, cement mixers, steamers, fork lifts, power conveyers, skate conveyers, wagons, and trucks.

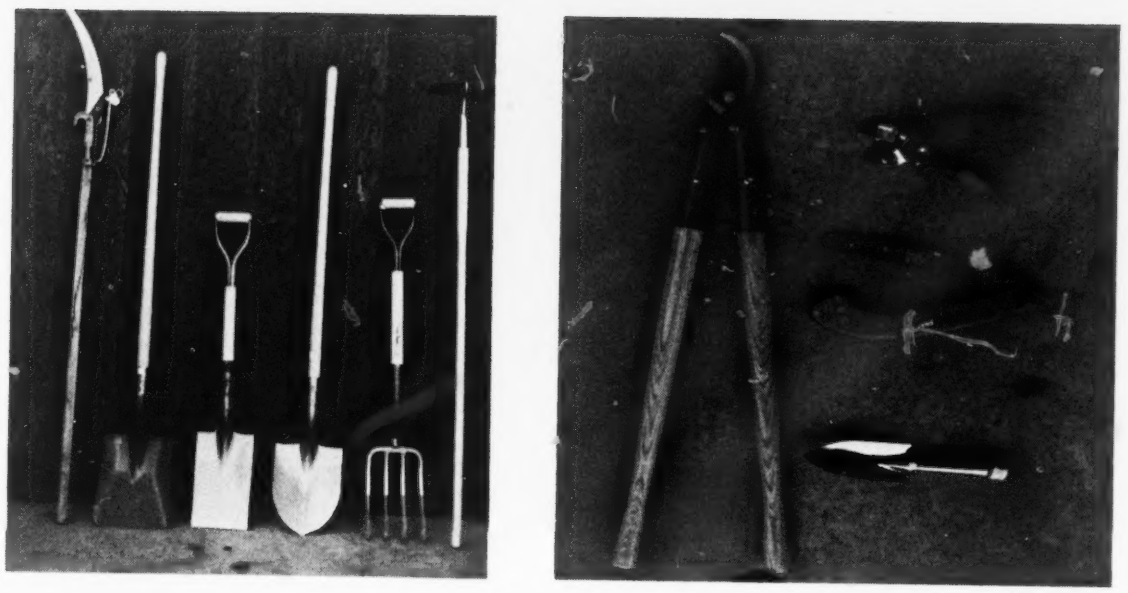

Figure 30. Hand tools commonly used in nurseries.

Some of the hand tools commonly used in nurseries are listed below, together with some notes about their desirable qualities:

Spade - tree digging, metal shank
Spade - shrub digging, metal shank
Spading fork - metal shank
Scoop shovel - metal shank
Shovel - metal shank
Planting bar - metal shank
Lopping shear
Hand pruners
Pole pruner
Garden trowel, welded metal shank
Grafting knife
Budding knife
Pruning knife
Nursery hoe
Rake
Pitchfork
Tree caliper
Knapsack sprayer
Hand duster (crank type)
Fertilizer injector

Supplies

Supplies are the materials that are expended in the processes of producing nursery plants for sale. It is important that the need for these supplies is anticipated several months before they will be used so that they will have been ordered and are on hand when needed. Supply items include plant material, containers, fertilizer, herbicides, soil and soil amendments, insecticides and fungicides, burlap and twine, labels, and shipping supplies.

Many nursery trees and shrubs are grown from seeds. The seeds may be purchased from firms that specialize in collecting and selling seeds from many sources. Most nurseries not only purchase seeds, but also collect seeds from specially selected plants which they maintain for this purpose. Understock for grafted plants may be grown from seed by the nursery, or seedling understock for grafting may be purchased.

Cuttings are usually started by a nursery from their own stock blocks of plants, although some are purchased.

Most wholesale nurseries propagate and grow their own stock to lining out size. Smaller nurseries usually buy liner stock which is big enough to be set directly in the field or to be planted directly into containers.

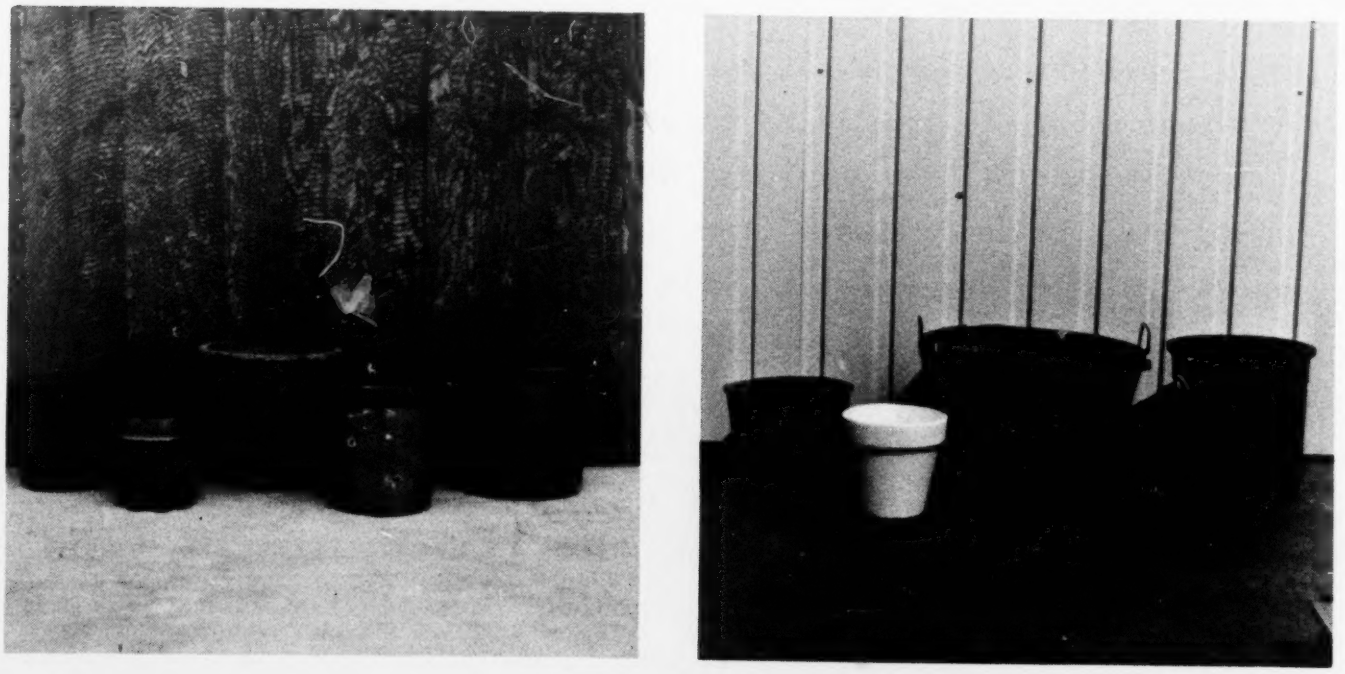

Figure 31. Examples of containers used for nursery stock.

Small containers for young stock may be clay pots, wooden flats or plastic pots. For container stock, metal, paper, or plastic containers are used. Purpose, size, durability, appearance, and price are things to be considered in the selection of the appropriate container.

For propagation purposes several types of planting blocks have been devised. These are discussed in detail in the Chapter 5, page 77.

Fertilizer must be stored in a dry cool place. The kinds used vary with the kinds of plants grown and the cultural techniques used. Most nurseries do not maintain more than one year's supply because fertilizer is bulky. The kinds used by many nurseries include: ground limestone, superphosphate, ammonium sulfate, potassium sulfate, long acting "complete" fertilizer mixtures in several analyses, soluble "complete" fertilizers for application in water, and small quantities of fertilizers providing individual trace elements, or mixtures of trace elements. Details on analyses and formulations and how to apply them are given in the units on field growing and container growing.

Herbicides may be applied in granular form or may be mixed with water and applied in liquid form. These materials during storage may give off funes that are toxic to plants, so they should be stored in a dry, cool place where there are no plants. Herbicides must never be stored in the same room with other pesticides or fertilizer because herbicide fumes from the air can be absorbed by them in sufficient amounts to cause injury when the contaminated material is applied to crop plants. The formulations that are used are given in the unit on field growing of nursery stock. A one year supply is usually kept on hand.

Sufficient soil for planting container stock in early spring is usually held under cover over winter. This is done so it will be available for use early in the year when the outdoor soil is frozen or too wet to be moved. Such soil amending materials as peat, perlite, vermiculite, sawdust, ground bark, and sand, are also stored under cover for the same purposes.

Insecticides and fungicides are usually stored in a separate, cool, dry, locked room for safety reasons. Sufficient quantities should be on hand for the needs of 1 year. Some 10 to 15 kinds are usually used in a nursery. The kinds used and the quantities needed vary with the kinds of

crops being grown and the location of the nursery. New pesticides are introduced each year, and each year the kinds of pests for which control is required may vary, so the inventory is constantly changing. When new pesticides are put into the storeroom, they should be dated with a wax crayon. This is to avoid the accumulation of pesticide materials that have lost their strength. The "shelf life" of pesticides varies considerably. Most of those in liquid or emulsified form should be discarded at the end of 1 year. Insecticides in dust or wettable powder form should be discarded at the end of 1 to 2 years; fungicides in dust or wettable powder form should be discarded at the end of 2 to 4 years. At the time of the annual inventory of pesticides, all outdated containers should be discarded. All pesticides should be stored in their original containers so that the directions for their use do not become lost. All containers, whether bags, cans, or bottles, should be stored tightly closed.

Figure 32. Plant identification tags for patented plants.

Burlap, or woven plastic substitutes, are needed for B&B stock. Binder twine, or similar material is used for tying the soil balls. A soft twine is used for holding the branches close to the main stem of trees and shrubs while they are dug and moved.

Plastic or metal tags, often preprinted with the kind, variety, and size of the plant, are kept on hand for labeling the plants. These tags may also carry a plant patent notice. Plastic ribbons, about 2 inches wide, in various colors, are often used for marking plants in the nursery for a crew that is assembling an order. Color labels are also used in color coding sizes for ease in assembling plants in the storage.

Shipping supplies that must be on hand include shipping boxes, waterproof packing paper, plastic film, moist shingletoe, moist sphagnum, twine, stakes (to prevent bending of packages), wrapping paper, shipping labels, glue, and marking pencils. Wooden shipping cases are also needed for large quantity shipments. Canvas tarpaulins and ropes will be needed for shipment of large size stock on trucks.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

References

Farm Power and Machinery Management. Laboratory Manual and Workbook, Third Edition, Hunt, D. Iowa State University Press, Ames, IO, 1960.

Machines for Power Farming. Stone, A. A., and Gulmin, H. E., John Wiley and Son, Inc., NY, 1957.

Plant Hardiness Zone Map. Mics. Publ. No. 814, Agr. Research Service U.S. Dept. Agr., Washington, DC

"Site Selection and Development" Sec. III Nursery Management Handbook, Furuta, T. Agr. Ext. Service, University California, Riverside, CA, 1969.

Audio-Visual Aids

Greenhouses and Related Structures, Agdex 200, 731, 1967, color slides and script. Curr. Materials Service, Ohio State University, Columbus, OH, $9.50.

Effect of High Ground, filmstrip (G37) McIntyre Visual Publications, P.O. Box 2017, North Main Street, Champlain, NY 12919, $6.50.

State Soil Survey Maps

State Rainfall Distribution Maps

State Population Distribution Maps

State Highway Maps

State Topographis Maps

Suggested Learning Activities

1. Using the hardiness zone, soil survey, rainfall, population, topographic, and highway maps, together with the criteria for choosing the location for a nursery, have the class determine several suitable locations for wholesale nurseries in your state.

2. With information from the state nursery association, have students indicate on a state map the locations of the major nurseries in the state.

3. Have each student make a scale drawing of a typical nursery layout.

4. Arrange to take a field trip, visit a local nursery and observe the physical plant and discuss its location, facilities and the equipment being used.

5. Furnish students with catalogs and pamphlets concerning nursery equipment and facilities.

6. Invite a nurseryman to the school to discuss the modern nursery physical plant.

7. Have students build a lathhouse for school use according to the plan that follows, or the plan given on pages 87-91 in Reference 12, "Developing a High School Program in Ornamental Horticulture": Vol. I, Nursery Management, Instructional Materials Program, Brown, H. C., California State Polytechnic College, San Luis Obispo, CA.

Suggested Placement Experiences:

1. If greenhouses are being constructed in the school area, check to see if they can employ a student as temporary help.

2. Check for nursery expansion projects in this area and seek placement of students for experiences.

3. Ask the employers of local nurseries to discuss the physical plant with students placed for experience.

Test

1. Define the word "nursery."

2. What climatic factors promote good nursery growth?

3. What are the physical factors to consider in selecting a site for a commercial nursery?

4. How important are roads and attractive entrances?

5. What are some important points to consider in arranging the layout for the different blocks of plants?

6. Make a sketch (to scale) of an ideal layout for a wholesale nursery.

7. Why is a soil map of the nursery site important?

8. Make and label a sketch showing different types of greenhouse suitable for nursery propagation.

9. What pruning tools are used by a nurseryman?

10. At what age should plants be sold?

11. What areas in the United States have the largest number of nurseries?

12. Give the purpose of the following structures:

Cold frame --

Display area --

Greenhouse --

Hotbed --

Lathhouse --

Service area --

Tool shed --

Work room --

Heeling-in beds --

CHAPTER 4

HOW PLANTS GROW

Objectives

The major goal of this Chapter is to understand how plants grow. To do this we must study plant structures, processes, and tissues--what they are, their development, and functions.

Students should know:

1. Plant tissues and their functions
2. How plants manufacture their food
3. How plants absorb water and minerals
4. How plants use and lose water
5. How plants develop new tissues
6. How environmental factors affect plant growth

Key Questions

1. What is a plant cell? plant tissue?
2. Give examples of plant tissues and their functions.
3. Explain how stems and roots grow in length and in diameter.
4. Give five parts of a plant and their functions.
5. How do plants manufacture their food?
6. Describe how absorption of nutrients takes place in plants.
7. What is transpiration?
8. Why must only well-drained soils be used for nursery production?
9. Why are light soils preferred for nursery production?
10. How do temperature, light intensity, and relative humidity affect plant growth?

Key Words

Absorption - the transfer of liquids and dissolved substances through cell membranes into the cells of a plant

Cambium - tissue by which the roots and stems increase in thickness.

Cell - the basic unit of structure in living things

Chlorophyll - the green colored parts of some cells

Corolla - the petals of a flower

Cutting - a part of a plant which will develop new growth to produce a new plant similar to the plant from which the part was taken.

Dormancy - the non-growing condition in a plant or seed due to unfavorable temporature, moisture or other conditions

Epidermis - the thin surface layer of tissue in plants

Nutrients - elements (nitrogen, phosphorous, potassium, etc.) which are necessary for plant growth and development

Ovule - structure of a flower which contains the egg cell

Petal - one of the parts of a corolla of a flower

Petiole - leaf stem or stalk

Phloem - a tissue of slender heavy-walled tubular cells in which food is transported downward from the leaves to the stems and roots.

Photosynthesis - the formation of sugars from water and carbon dioxide in green plants with the aid of light energy

Pistil - the female part of a flower

Pollen grain - the sperm cell of a flower

Pollen tube - the tube which grows out of a pollen grain when it lands on the stigma; it grows through the stigma and style to the ovary of a flower

Pollination - the transfer of the pollen grain of the stamen to the stigma of the pistil

Root hairs - slender thin-walled projections from cells in roots; these cells are located at the surface of the tip of a root; they function in absorbing nutrients and water

Seed stratification - pretreatment of seeds in a moist medium at low temperature for several months to give rapid germination when sown

Sepal - one of the modified leaves which surround the corolla of a flower

Stamen - the male part of a flower

Stigma - the part of a pistil that receives the pollen in pollination

Stomate (plural-stomata) - minute openings in leaves which permit the passage of air and water vapor into and out of leaves

Style - the part of a pistil between the stigma and the ovary

Tissues - groups of cells which look the same and have a common function

Transpiration - loss of water vapor primarily through the leaves

Vacuole - the central part of a cell containing water, dissolved materials and other substances

Vascular - refers to structures such as the veins in leaves of plants and blood vessels in animals. Leaf veins contain both xylem and phloem

Xylem - tissue of large, heavy-walled, long cells through which water and minerals are transported from the roots to the stems and leaves of plants. The wood of a tree is xylem tissue

How Plants Grow

If a nurseryman is to offer good quality plants to his customers, he must understand how plants grow. By understanding how they respond to their environment, he can make changes in the environment that will bring about rapid, healthy growth. He needs to know how stems and roots become longer and how they become thicker. He needs to know how the roots, stems, and leaves work together in the production and transport of plant foods. He needs to know how plants make their own food. He needs to know

how plants get and lose water. He needs to know what minerals are needed by the plants, and the amounts required.

Lastly, he needs to know what changes he can make in the environment to bring about desirable changes in the growth of his plants.

How Stems and Roots Become Longer.

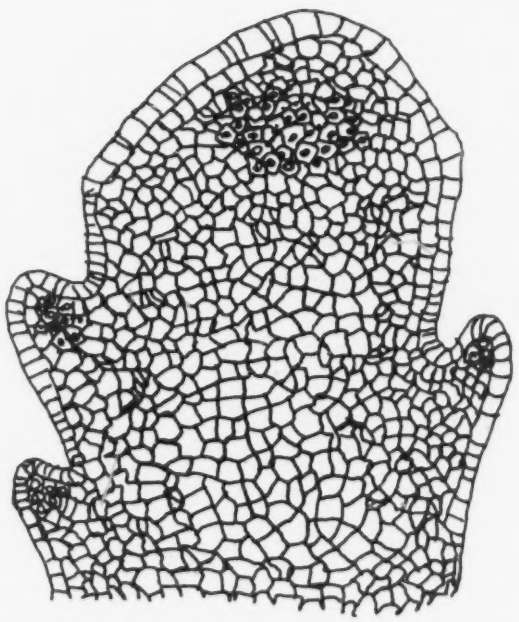

Figure 33 A stem tip

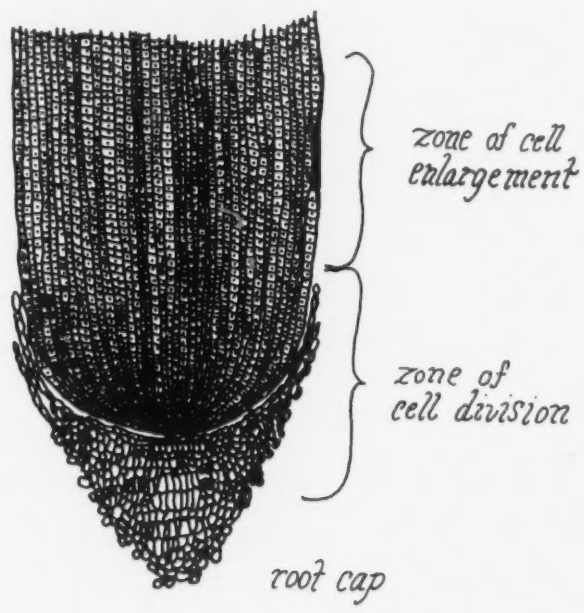

Figure 34. A root tip.

Stems and roots become longer because of two things - the starting of new cells and the enlargement of those new cells. Cells, are microscopic, somewhat cube-shaped units which are the building blocks ing blocks of all living things. Figures 33 and 34 show how stems and roots become longer. The dark zone just back from the tip is a dense area in which each very tiny cell becomes two cells, simply by forming a new cell wall across the middle. These new cells enlarge to many times their original size, stem cells pushing the stem tip upward or root cells pushing the root tip downward. They are inflated by water just as a balloon may be inflated with air. As you might expect, a plant that does not have sufficient water will have smaller cells than one with adequate

is why plants that are not artificially watered make short growth in a "dry" year.

Tissues are groups of cells that look alike under a microscope. Each such group serves the same function. In figure 35 we see a cross section of a leaf blade in which some of the important tissues are labeled.

The uppermost rows of cells make up a tissue called the epidermis. It has a waxy surface layer that protects the more delicate internal tissues.

The palisade tissue (or layer) is next, with long cells that contain green pigments (chlorophyll). The plant manufactures food in this tissue.

Below that is a spongy layer of cells, arranged in a loose manner with open spaces between them. These cells serve as food storage cells and when these cells are fully filled with water they also serve to make the leaf firm. Moist air fills the open spaces.

Within the spongy layer are bundles of cells that are referred to as veins. They contain the water-conducting tubes (long cells called xylem) and food conducting tubes (phloem). Water, together with dissolved minerals, is moved from the roots to the stems and leaves through the xylem. Food (mostly dissolved sugar) is moved from the leaves to other

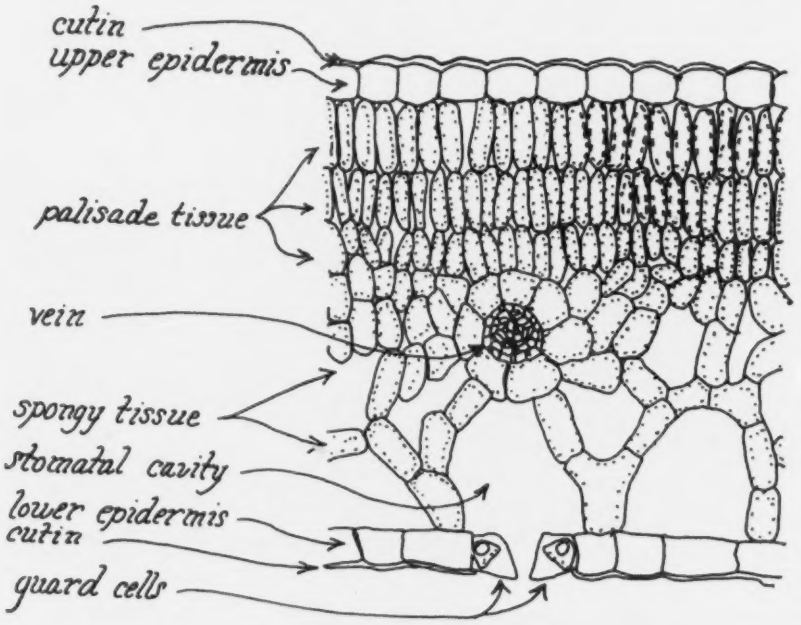

Figure 35. Cross section of a leaf.

parts of the plant through the phloem. Many of the cells in the veins have heavy walls which help keep the leaf stiff. If the cells of the leaf blade become "flabby" because they are not fully inflated with water, the leaf becomes soft and is wilted.

The lower epidermis is like the upper epidermis except that scattered here and there are some special pairs of banana-shaped cells which control the opening and closing of microscopic holes in the leaf. Water and air pass through these holes (called stomata). The stomata are open only during daylight hours, and considerable water vapor passes through them to the outside air. This loss of water through stomata is called transpiration. Although there is some doubt about how helpful the water loss is, the exchange of air is important. Stomata usually are closed at night.

How Stems and Roots Become Larger (in Diameter).

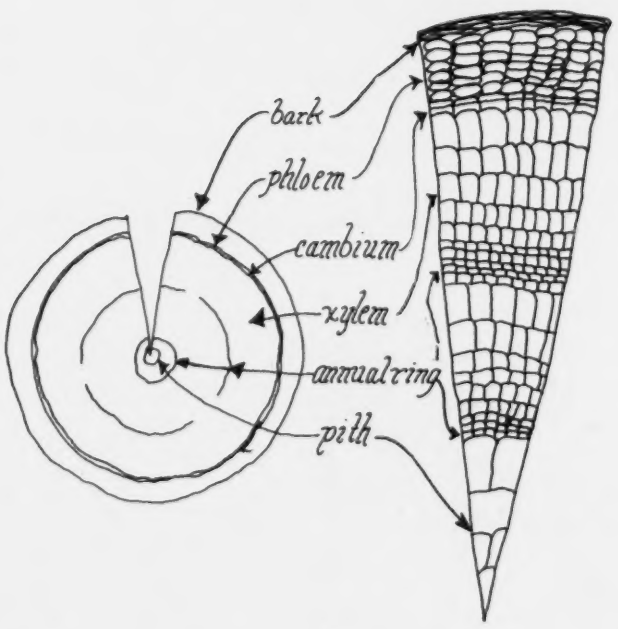

Figure 36. Cross section of a woody stem.

Although we are aware that trunks of old trees are larger in diameter than trunks of young trees, we often do not realize that the same is true of branches of woody plants. Just how do they become larger in diameter? The answer is illustrated in Figure 36. Under the bark of a tree there is a cylinder of very small soft cells similar to those at the stem tip and root tip. Each cell in this tissue also divides by laying down a wall across its middle, to produce a new cell. The tissue in which this

occurs is called the cambium. New cells are formed on both sides of the cambium cylinder. The ones laid down toward the inside become large, heavy-walled tubes that make up the xylem tissue. Toward the outside of the cambium cylinder the cells that are produced are smaller, but heavy-walled. These make up the phloem tissue. When phloem cells die they become bark. The cambium tissue produces small diameter xylem tubes in the fall, is nearly inactive in winter, and produces large diameter xylem tubes in the spring. The "rings" we see in a tree stump are these alternate layers of small cells and large cells produced each year. For this reason, the age of a tree may be told by counting the rings on the stump. In a very dry summer, or with a tree in poor health, the width of the ring for that year will be narrower than usual. Since nursery trees are sold according to the diameter of the trunk (caliber), it is important that the nurseryman provide adequate water and minerals for rapid growth.

Parts of a Plant

The parts of a plant are called "organs." The organs of a plant as shown in Figure 37 are: root, stem, leaf, flower, fruit, and bud. Each serves a different function in the plant.

Roots serve to anchor the plant in the soil. Just back of the growing tip on roots of most kinds of plants, the epidermal cells send out long thin-walled projections called root hairs (see Figure 38). Water, and the minerals dissolved in the water, pass through these thin walls. This very weak solution eventually goes into the xylem where it is distributed all through the plant. Each root hair lives only about 10 days. Since they are formed only from young cells, the only way that a root can continue to have a supply of them is by continuing to grow. If the roots

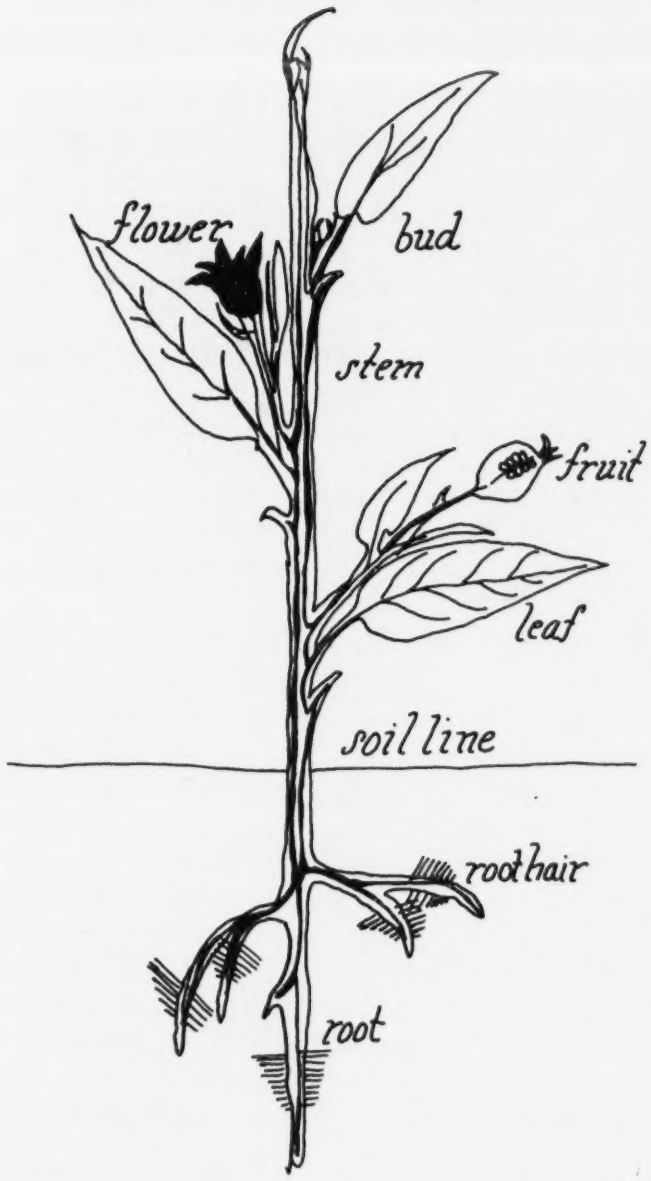

Figure 37 Parts of a plant.

are not in good health the growth of the whole plant is slowed. A peculiar thing about root hairs is that they die in a few hours if they are not surrounded by water and air. Only a soil with both water and air spaces, as shown in Figure 39, provides this condition.

Stems serve to hold the plant in an upright position and contain the tubes through which water, minerals, and food are transported.

Branches occur at the place where side buds have been formed. These side buds are in leaf axils. Often, these lateral buds will not start growing unless the main bud at the tip of the shoot is removed. Nurserymen often remove shoot tips to induce the side (lateral) buds to grow, which produces a more compact, branched plant instead of one with a single stem.

Leaves are the main area in a plant in which food is manufactured. They occur in many shapes and sizes, but they are all similar on any one plant. The stem-like piece that connects the leaf to the plant is called the petiole. The broad, flat surface is called the blade of the leaf. On needle evergreens the blade and petiole look the same.

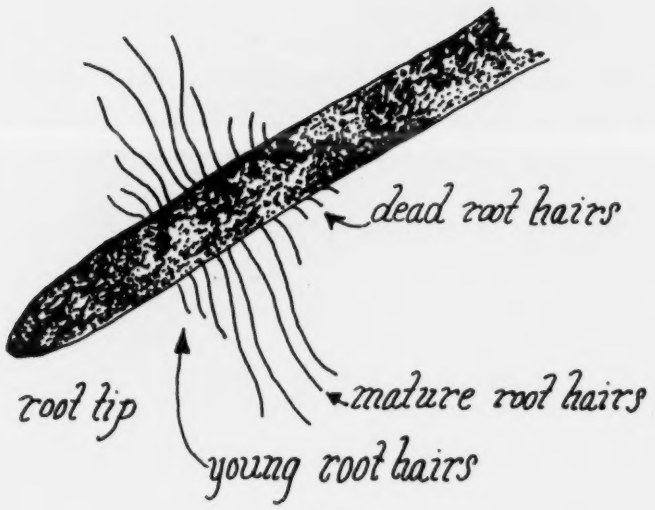

Figure 38. Root hairs.

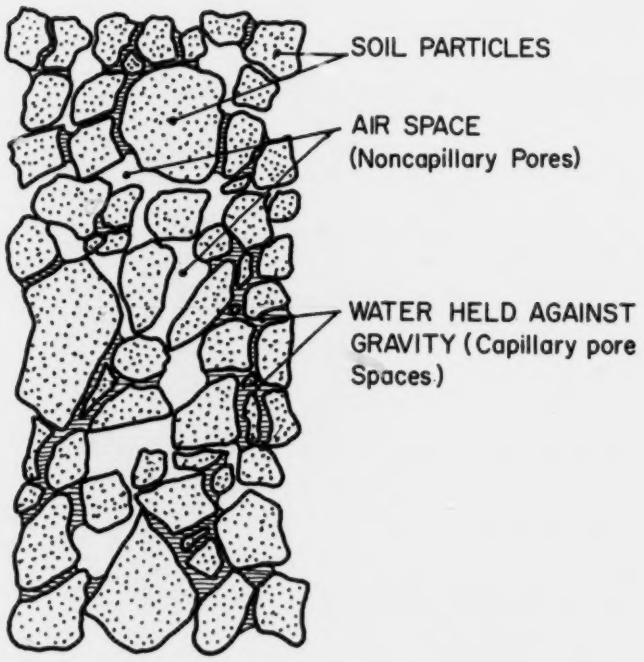

Figure 39. Water and air in soil.

Flowers are the reproductive parts of plants. Some are very elaborate, and others are simple. They serve to produce seeds. Most woody plants have complete flowers; that is, both the male and female parts are found in the same flower. Others have male flowers and female flowers (incomplete) on the same plant; while in others one plant has only male flowers and another has only female flowers. In holly, for example, the sexes are in separate plants. Only female holly plants bear the colorful fruit. However, at least one male plant must be planted in the vicinity of each group of female plants to provide the pollen for causing the fruit to develop. Female Ginkgo trees, on the other hand, are seldom planted because the ripe fruit has a very offensive odor.

Some nursery plants, such as holly, are grown especially for their colorful fruit. Others, such as crabapples, have both colorful flowers and colorful fruit. Fruit results from the pollination of flowers, causing fertilization of the egg in the ovary. The resulting fertilized egg, often together with other closely attached parts, enlarges to become a fruit con-

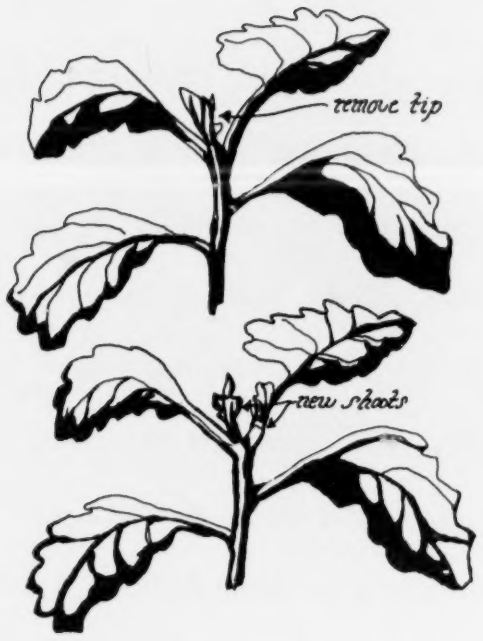

Figure 40. Bud removed to give branches.

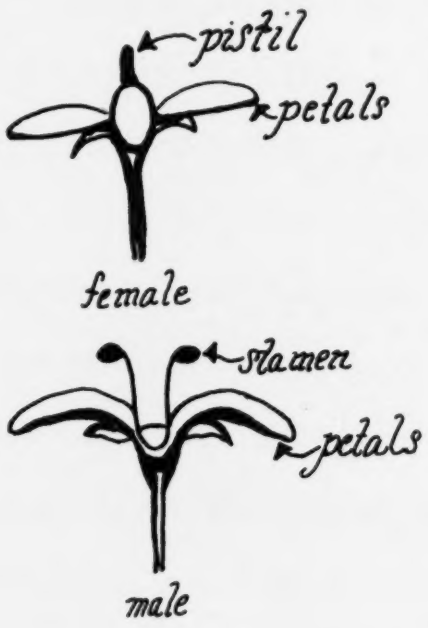

Figure 41. Holly flowers.

taining from one to many seeds. The seeds may be used for starting new plants similar but not identical to the one from which they came.

How Plants Make Food

Green plants have the ability to make food. If you trace the "food chain" backwards, you will find that ultimately all other forms of life derive their food from green plants. Although people often say they are "feeding" plants when they apply fertilizer, actually they are only supplying the minerals the plant needs in order to use the food it manufactures. The green pigment (chlorophyll) has the unique ability to convert carbon dioxide and water into sugar and oxygen (plus a little water) in the presence of sunlight. The water used in this food manufacturing comes from the roots, while the carbon dioxide comes from the air that enters the stomata. The sugar is transported to other parts of the plant where it may be stored as starch or may be converted into amino acids, proteins, fats, or other substances. All nursery plants require full sunlight in order to carry on photosynthesis and grow well. Some broadleaved evergreens, such as azaleas

and rhododendrons, must be protected from full sunlight in winter to avoid burning of the foliage from the stress of overheating followed by chilling.

Minerals

The fertilizer we apply to plants is used in changing the sugar and starches to other materials that are stored or that become parts of the "building blocks" in the growth of the plant. Table 5 names some of them and indicates how they are used by the plant.

Table 5 Some minerals and how they are used by plants.

Mineral ⟶	Substance Formed ⟶	Use
Nitrogen	Amino acids	Proteins in cells
Phosphorus	Proteins	Proteins in cells
Potassium	None	Catalyst
Calcium	Calcium pectate	Cement between cells
Iron	Chlorophyll molecule	Catalyst
Magnesium	Chlorophyll molecule	Catalyst

A number of additional minerals - sulfur, manganese, boron, molybedenum, copper, and zinc are also needed, but only in "trace" amounts.

Controlling Environment

A nurseryman can control the growth of plants for his own purpose if he understands the things that influence how they grow and can adjust those things to get the results he wants.

The next several paragraphs give examples of how a nurseryman controls the growth of plants by adjusting temperature, light, relative humidity, mineral levels, controlling pests, and pruning.

Temperature influences the growth of plants. Temperatures that are too high may be harmful to young plants of certain species. The nurseryman overcomes this by growing seedlings of rhododendrons and azaleas under

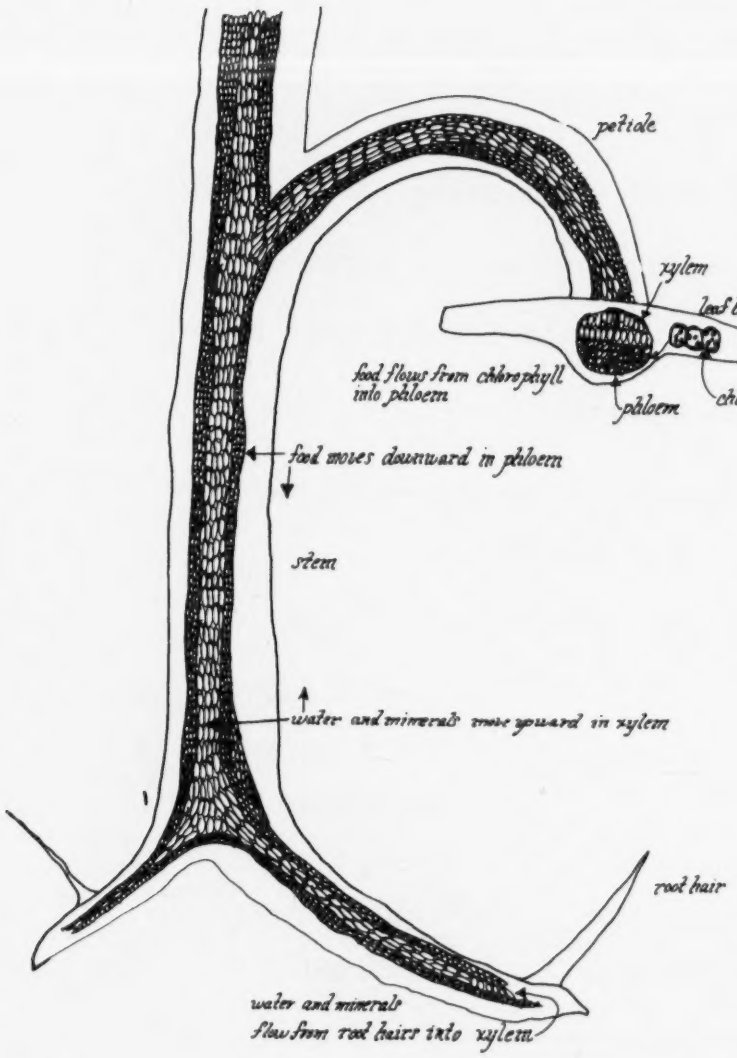

Figure 42. The movement of food, water, and minerals in plants.

lath shade. Root growth on cuttings is most rapid if the temperature at the base of the cuttings is higher than the temperature of the leafy part of the cutting. Electric heating cables, or other devices, are used to provide "bottom heat" in propagation benches. Certain seeds must be treated with low temperature (35°F) for several months before exposure to higher temperatures for growth. Nurserymen store them moist and cold to overcome this dormancy by a method called "stratification."

Light is essential for photosynthesis and growth. Nurserymen grow most of their plants in full sunlight for this reason. Nurserymen also space out the plants in a planting so that the plants do not shade one another. This spacing not only allows more rapid growth, but also promotes compact,well-proportioned plants.

The relative humidity and moisture requirements of cuttings while they are rooting are very exacting. A cutting can absorb water only very slowly through the cut stem, so the propagator tries to do everything he can to conserve the moisture that was in the cutting originally.

Figure 43. A "mist" propagation system.

Cuttings are taken from the stock plants during early morning when the moisture content is high. The cuttings are carried in wet paper or moist containers. They are quickly placed in the propagation medium before they wilt. A "mist" system, Figure 43, is used to reduce water loss by evaporation (transpiration) from the leaves on the cuttings.

Balled and burlapped nursery stock being held for several days before shipping is usually placed in a shaded location, and is sprinkled over the top several times a day to compensate for the water lost from the leaves and surface of the burlap covering the soil ball.

Bare-root stock held over winter in storage bins must be maintained in a high relative humidity to avoid killing the roots. For the same reason, these roots must be wrapped in moist shingletow or similar material when they are packed for shipping.

A nurseryman carefully selects the soil he uses, and improves it by using green manure crops in his crop rotation plan. He does this because soil moisture and air-holding abilities must be good if healthy root systems are to be produced.

The mineral levels in the soil are checked every 1 to 2 years by soil tests. Container-grown stock is usually fertilized lightly with each watering. If even one mineral required for growth is lacking, the plant will not grow satisfactorily.

Insects and diseases can render nursery plants unsalable by unsightly damage as well as by reducing plant vigor. A nurseryman controls them by applying appropriate chemical materials, by steaming his soil (if possible), and by being constantly on the watch for disease and insect pests.

Weeds, because of their rapid growth, remove minerals and water that are needed by the nursery plants. They may also provide a "home" for unwanted insects and diseases. Excessive weed growth may also shade small plants in the field. Cultivation and the use of weed controlling chemicals (herbicides) give an environment more favorable for nursery plants.

Nurserymen often prune their plants in order to give the plant a more desirable shape. They also prune the roots of field grown plants, for a different reason. Figures 44 and 45 show that this induces a more compact root system which results in less root loss when the plant is finally dug and sold. Because a nursery plant that has been properly

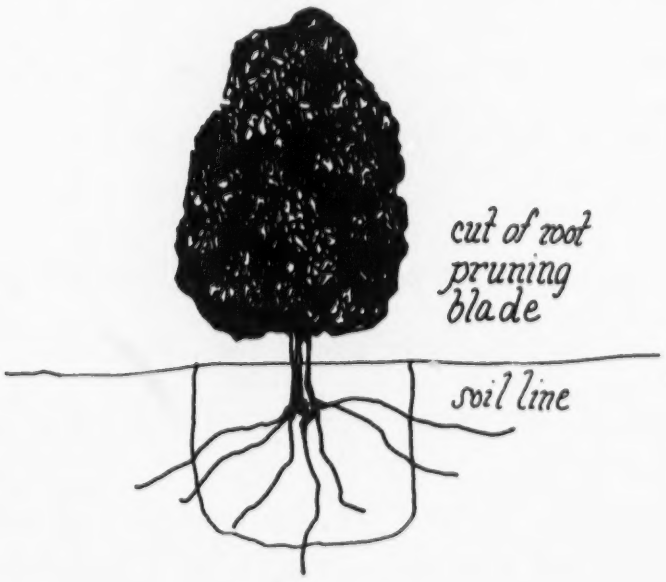

Figure 44. Shrub before root pruning.

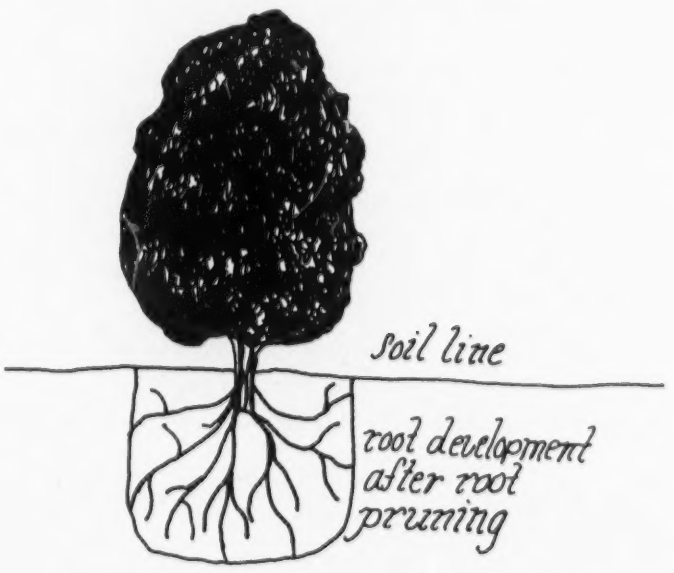

Figure 45. Root branching after root pruning.

root pruned is much more likely to grow well after being planted, the nurseryman can sell them with confidence that the customer will be pleased with them.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Reference

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Plant Propagation. Mahlstede, John P. and Haber, Ernest S. John Wiley and Sons, Inc., N.Y., NY, 1957.

Audio-Visual Aids

"Speaking of Trees," motion picture, 16 mm., sound, 19 min., H. D. Schmid, Davey Tree Expert Co., Kent, OH 44240.

"Sexual Reproduction in Plants," filmstrip, color, 15 min. script. De Kalb Agricultural Assn., Inc., Educational Division, De Kalb, IL 60115.

"Flower Anatomy," (labeled Yucca filamentosa flower embedded in plastic block), No. 8 block, 56W7000, $15.25, Wards National Science Establ., Inc., P.O. Box 1712, Rochester, NY 14603.

"Plant Reproduction Collection," (vegetative reproduction specimens mounted in plastic block), No. 8 block, 56W7000, $15.25, Wards National Science Establ., Inc., P.O. Box 1712, Rochester, NY 14603.

"Ash Flower," (staminate and pistillate flowers, preserved specimens). Turtox Bilogical Supplies, General Biological Supply House, Inc., 8200 South Hayne Ave., Chicago, IL 60620.

"Seedling Development," (12 seedlings of 6 species in 2 stages of early growth, preserved). 25D66. $22.50. General Biological Supply House, Inc., 8200 South Hayne Ave., Chicago, IL 60620.

"Riddle of Photosynthesis," motion picutre, 16 mm., sound 14½ min. U.S. Atomic Energy Commission, Public Information Service, 376 Hudson Street, N.Y., NY 10014.

"Making the Most of a Miracle," (plant nutrition), motion picture, color, sound, 16 mm., 27 min., National Plant Food Institute Film Department, 1700 K Street Northwest, Washington, DC 20006.

"Atomic Greenhouse," (how nutrients are used by plants) motion picutre, 16 mm., sound, 12½ min. U.S. Atomic Energy Commission, Public Information Service, 376 Hudson Street, N.Y., NY 10014.

Suggested Learning Activities

1. Draw a chart of a complete flower, ask students to help you label each part correctly, then ask the students to bring an actual specimen of a complete flower which they can study by comparing it with the drawing.
2. Have students place seeds of dicots between a moist blotter and the inside walls of a glass container. About ½ - inch of water should be kept in the bottom of the container at all times. Students can observe the growth of the roots, especially the root hairs. To show that roots absorb nutrients, color the water red or blue. The water absorbed by the plant is indicated after a while by changing of the color of the plant as the colored water goes up to the stems and leaves.
3. To illustrate that water evaporates from plants, grow a number of identical coleus plants in plastic pots of the same size. For a demonstration, water them all until water drains freely. Then have students weigh them to the nearest grain or 1/10 ounce at hourly intervals for several days. Grow an identical set of plants in clay pots, and using the same technique, determine the rate of water loss. Why is there a difference in speed of water loss?

   Some of the seedlings may be left unwatered for some time for students to observe the importance of water to plants. Wilting of the plants may be observed.

4. Have students prepare microscope slides of the upper and lower epidermis of leaves of Tradescantia, which maybe easily peeled from the leaf. Have them identify the stomata. How many do they find in a one view of the upper epidermis? The lower epidermis? Ask the students to find out what causes them to open and close.
5. Have each student grow 12 coleus, or some other rapidly growing plant. When the plants have developed about 6 nodes, have each student remove the stem tips of 6 plants, and allow the other 6 to grow naturally. Ask the students to examine the plants carefully every 2 or 3 days and record what happens. When the laterals have developed 2 nodes repeat the process and compare with the unpinched plants.
6. Grow a few poplar or willow trees in your nursery for a demonstration of girdling. The trees will need to be 2 or 3 years old for demonstration. In the spring remove a band of bark (to the xylem tissue) about 2 to 3 inches wide from the trunks of some trees. Also have students cut several other trees to the ground. In the fall have students examine the trees to record what has happened. The following spring, about mid-May, have them examine and record results. Which trees lived? Which died? Why did they die? Why did it take a year? Rabbits and mice often girdle certain tree species in a nursery. How can this be prevented? How can a girdled tree be repaired?
7. In a greenhouse or on a classroom window sill have students grow coleus, seedling junipers, or Impatiens. Grow them properly to

about 4 to 6 inches high, then withhold fertilizer from half the plants, while continuing to fertilize the remainder properly. Have students record the plant heights, and note any differences at weekly intervals over a 3 or 4 month period. Which plants grew the most rapidly? Which plants developed the most lateral growth? What other differences were recorded? Discuss the importance of adequate fertilization of nursery plants.

Test

1. What is the function of the stomata?
2. What do you call the green pigment in the leaves of plants?
3. Give the function of the cambium layer.
4. How do phloem and xylem cells differ from each other?
5. How can one determine the age of a tree?
6. What should be done to increase the number of stems a plant has?
7. How do roots increase in length?
8. When does wilting of the leaves occur?
9. Give at least two functions of the following: roots, stems, leaves, and flowers.
10. How can you tell the stamen from the pistil?
11. What is pollination? Describe how it takes place in plants.
12. What factors are essential in photosynthesis?
13. What are nutrients? Where are they found?
14. When does absorption of water by the roots take place?
15. At what time of the day is transpiration in plants the fastest?
16. In what part of the plant does transpiration take place?

17. Give two examples of how the nurseryman can get a plant to produce the kind of growth that he wants.

CHAPTER 5

PROPAGATION OF NURSERY STOCK

Learning Objectives

1. To select and operate the specialized equipment used in propagating nursery stock.
2. To propagate nursery stock by cuttings, grafting and budding.
3. To propagate nursery stock from seeds.
4. To care for young plants.

Key Questions

1. What facilities and equipment are needed to produce nursery stock from cuttings?
2. Why are some plants propagated asexually?
3. How does budding differ from grafting?
4. What is the difference between hardwood and softwood cutting?
5. How does the time of year that a cutting is taken affect rooting?
6. What other environmental factors regulate the propagation of cuttings?
7. How do growth promoting substances affect rooting?
8. What factors should be considered when collecting seeds?
9. What is meant by "stratification" of seeds?
10. What special care is needed for rooted cuttings and seedlings?

Key Words

1. Budding - the vegetative reproduction of plants by placing a leaf bud of the desired plant on the root stock of another plant in such a way that the two unite and grow
2. Cultivar - plants that are true to type from seed or vegetative propagation; a variety
3. Cuttings - a vegetative portion removed (cut from the plant) for propagation

4. Division - the process of cutting a clump type of plant into sections
5. Graft - vegetative propagation by which a stem portion of one plant, having 2 or more vegetative buds, is joined with the roots of another plant to form one new plant
6. Layer - a layered stem
7. Layering - the development of roots on a stem placed partially underground while still attached to the parent plant
8. Node - the position on the stem where leaves and buds are located
9. Scion - the upper piece of a grafted or budded plant (it forms the above ground part of the plant)
10. Seed - an embryo or baby plantlet in a dormant condition and only requiring the right conditions to stimulate it into growth and development
11. Understock - the lower piece of a grafted plant (it forms the underground part of the plant)

Propagation of Nursery Stock

The primary function of a wholesale nursery is to start small plants and grow them to marketable sizes. Many nurseries simply purchase seedlings, liners, and grafts from propagation specialists. Other nurseries may do their own propagating to produce the small plants that they require. A few specialized wholesale nurseries propagate plants as their only activity. In any case, a person interested in the nursery business should know how nursery plants are propagated. Many people find plant propagation a fascinating activity.

There are two basic ways that plants can be propagated. If the plants are started from seeds, the method is referred to as sexual propagation. If a part of a plant other than a seed is used to produce a new plant, it is called vegetative propagation.

This chapter will cover the specialized propagation equipment used, vegetative propagation, sexual propagation, propagation methods for specific plants, and the care of young plants after growth has started and until they are large enough to go into the field or containers in which they are sold.

Specialized Facilities and Equipment

The propagation of nursery plants from seeds, cuttings, grafts, or other means, may be done in enclosed spaces such as greenhouses or coldframes, or it may be done in outdoor beds. In certain special cases it may be done directly in the field. The young plants, depending upon their requirements, may be grown in open beds, shaded beds, lathhouses, or lined out in the field.

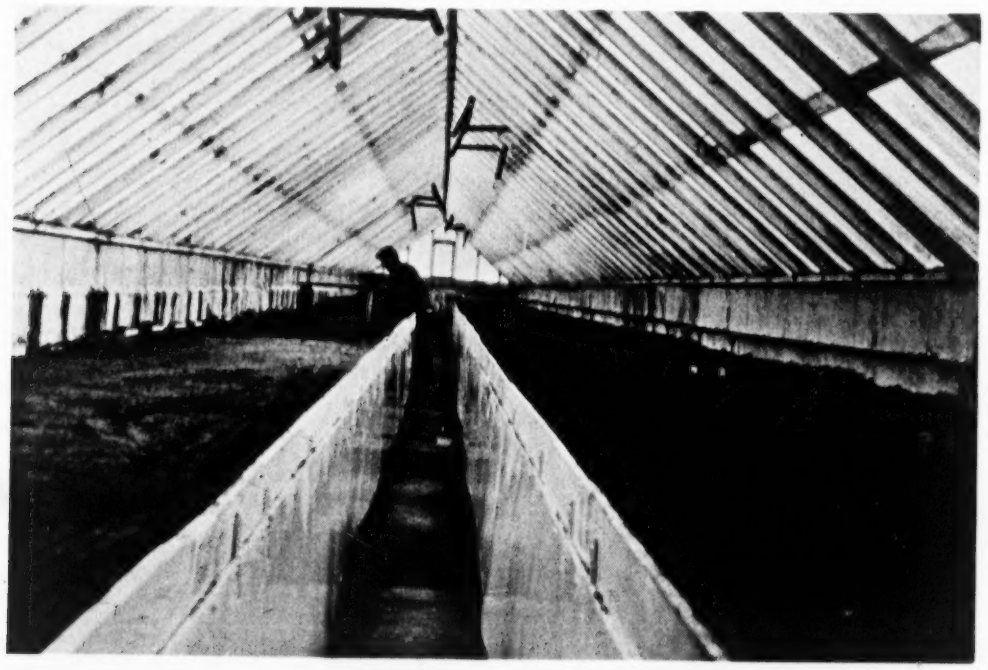


Figure 46. A propagation greenhouse at a nursery. Note the cloth skirt to enclose heated air under the benches.

Propagation greenhouses are discussed in detail on page 43. These greenhouses must be shaded in summer by the use of shading compound applied to the glass, or netting, or lath shade over the outside. These greenhouses are small so that a high relative humidity can be maintained in them. The heating system must be capable of holding any temperature from 40° to 70°F within a plus or minus variation of 1°F. A circulating hot water system is ordinarily used to meet these requirements. The benches are usually 4 to 6 inches deep. The propaga-

tion medium may be medium grade sand, peat, expanded pumice, expanded mica, or mixtures of these. Pressed peat containers filled with an appropriate medium are often used because the started plants can be transplanted with the container. Pressed peat blocks may be used in the same way for cuttings or seedlings. For more details read pages 28-33 in Reference 36. The temperature of the propagation medium is maintained about 10°F above the nighttime air temperature in the greenhouse by means of thermostatically controlled plastic-covered electric heating cables. An alternate method for heating the medium is to enclose the space under the benches with a cloth skirt to retain warm air from the heat pipes. Each bench is usually equipped with an overhead water pipe on which special misting nozzles are mounted at 3-foot intervals. The water in these lines is turned on at

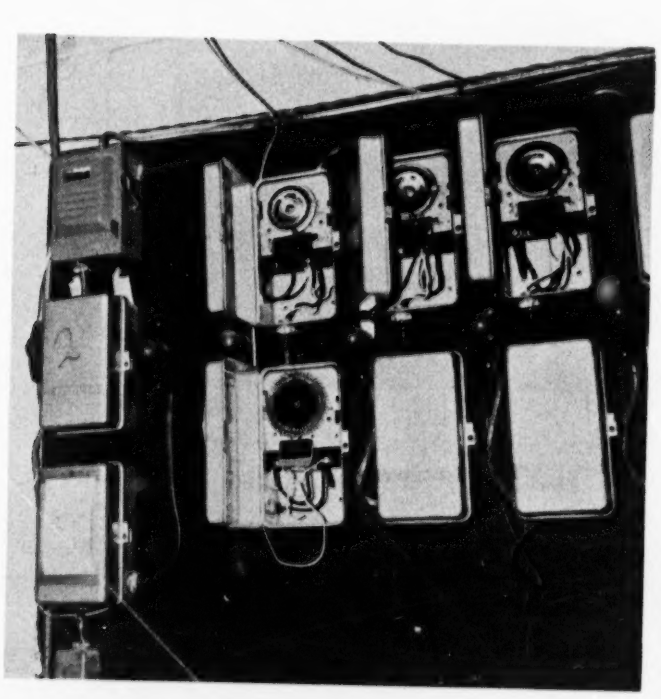


Figure 47. Upper timers - 24 hours; lower timers, 30-second or longer intervals every 30 minutes.

Figure 48. Mist in operation over holly cuttings.

intervals to maintain a high relative humidity and to keep the rooting medium moist. The frequency of operation may be regulated by a time clock, usually set to turn it on for 4 seconds in every 4 minutes. The amount of water applied must be carefully adjusted to avoid excess leaching of the propagation medium.

Coldframes as described on page 45 are sometimes used in late spring or early summer for propagation purposes. When used for this purpose,

they are equipped with mist propagation equipment in the same manner as a propagation greenhouse. Coldframes are often covered with lath or other shade material to prevent high temperatures and rapid evaporation. These frames may also be used for wintering young plants.

A workroom, usually called a "headhouse," provides workbench space and storage for equipment and supplies. Some of the special equipment and supplies needed for propagation include: grafting knives, budding knives, pruning shears, seed cleaning screens, buckets, rubber or plastic ties for grafting, small pots, fertilizer, growth-inducing substances, growing medium ingredients, flats, soil steamer, pesticides, and labels.

Propagation by Vegetative Means

Vegetative propagation is the process of growing a new plant by using parts of an established plant, such as roots, stems, or leaves. These parts are induced to develop roots and shoots which grow into a new plant. This propagation is asexual in that it does not involve the possibility of a change in the genetic make-up from that of the original plant. Vegetative propagation is accomplished by cuttings, grafting, budding, layering, and division.

Cuttings

Cuttings are portions of stems, leaves, or roots cut from mature plants. They are placed in a moist, warm rooting medium in a greenhouse or in a coldframe with a high relative humidity and slightly reduced light intensity. Roots usually form on the cuttings in 4 to 8 weeks. Propagation by cuttings has several advantages over growing plants from seeds. The rooted cutting is always a plant with characteristics that match those of the stock plant from which the cutting was taken. This is particularly important in maintaining the true type of a named and patented cultivar. Another advantage is that many plants will produce a large plant faster from a cutting than from seeds; yew is a good example. Cutting propagation may be the only practical way to produce plants having the desired sex, as in Holly (females needed) or Ginkgo (females undesirable).

If automatic controls are used for the maintenance of moisture and temperature, very little labor is required from the time the cuttings have been placed in the propagation medium and until they are removed from it after roots have formed.

The propagation medium must be one that is loose enough to maintain adequate amounts of air for growth of new roots; but at the same time it must have a high moisture holding capacity so that the new tissues are never deficient in water. If it is poorly drained, the cuttings may rot. The pH must be in the 6.0 to 6.5 range. Nutrients are of little value to the plants until after roots have formed. Depending upon the plant being propagated, the availability of materials, the management practices being followed, and the requirements of the plants involved, the following mediums are often used:

a. medium grade sand
b. peat
c. m. g. sand peat
d. expanded mica and peat
e. expanded pumice and peat
f. expanded mica, pumice and peat

Cuttings of some ornamental plants do not form roots readily. Root inducing compounds are available and are used to speed rooting, increase the number and size of roots, and to insure a higher percentage of rooted cuttings. These compounds will not induce roots to form on cuttings that would not otherwise eventually form roots. Neither can the use of them take the place of good cultural practices. These compounds often include as the active ingredient(s) indolebutyric acid (IBA) and/or naphthaleneacetic acid (NAA). They are often used in a mixture. The three methods of application are the powder method, the quick dip method, and the soaking method.

In the powder method, the basal ends of the cuttings are dipped into the powder (the carrier is talc), and the excess powder is knocked off by tapping the cuttings with the finger. The material must not be deposited in the leaf axils, or shoots will fail to develop at all.

In the quick dip method, the same technique is followed, but a concentrated solution of the root-inducing material is used instead of the powder.

The soaking method is used for hardwood cuttings with a slow penetration rate. In this method, bundles of the cuttings are placed upright in shallow containers of dilute solutions of root-inducing materials for

periods up to 24 hours.

Immediately after treatment with root-inducing materials, the cuttings are inserted (stuck) into the propagation medium. More details about the use of these materials are found on pages 305 to 310 in Reference 35.

Softwood cuttings generally root quicker and more easily than other kinds of cuttings. Softwood cuttings are taken from terminal parts of the stems while the plants are in active growth in late spring or early summer. The appropriate stage of development is when the shoots are just stiff enough so that the pieces can be readily snapped off with the fingers. Early morning is the ideal time to take the cuttings because they are filled with water at that time and air temperatures are low enough to delay wilting. Terminal parts of the stem are used. The leaves are not trimmed or removed at that time. The cuttings must be kept cool and moist. Clean plastic bags or clean, moist burlap may be used to store the cuttings temporarily. A cool, shaded place should be used during preparation of the cuttings for sticking. The cuttings are made from 3 to 5 inches in length, as shown in Figure 49. A sharp, thin-bladed knife should be used to make a basal cut about ½ inch below a node. Leaves are removed from the basal 1/3 of the cutting because this portion will be inserted into the medium, and buried leaves rot easily. Softwood cuttings may be treated with low concentrations of root-inducing materials to promote faster rooting. In many cases, softwood cuttings form roots readily without the use of these materials.

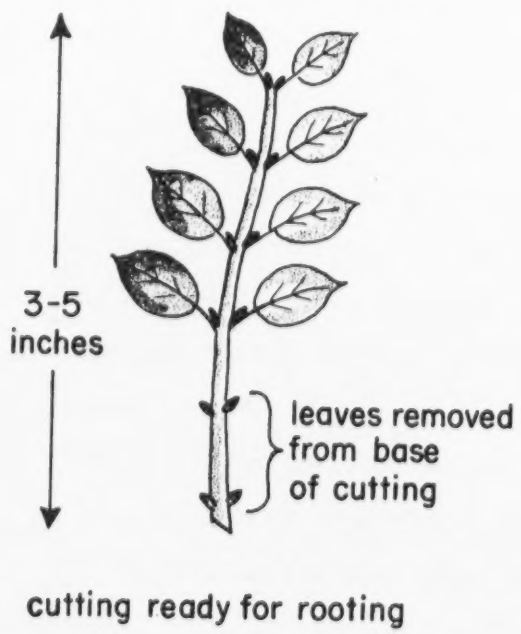


Figure 49. Softwood cuttings are 3-5 inches long; lower leaves are removed.

Greenwood cuttings are taken when the stems are no longer elongating rapidly. In this case the cuttings must be cut rather than broken from the plants. The leaves

are fully expanded and firm, and the stems are hard. Greenwood cuttings are usually made in midsummer. They are handled in the same manner as softwood cuttings. The use of rooting compounds speeds rooting of these cuttings.

Hardwood cuttings are taken in late fall and winter from plants that have stopped growing and have formed woody, hard stems. Hardwood cuttings of deciduous plants are made after the leaves have dropped in the fall until early February. Hardwood cuttings taken after early February are likely to develop top growth more rapidly that root growth, resulting in such a severe moisture stress that a very high percentage of rooted cuttings are likely to die after transplanting from the propagation bench. The cutting material should be selected from vigorous, healthy plants that are growing in full sunlight. The cuttings should include only wood from the past season's growth. Most nurseries maintain stock blocks of plants set aside for propagation purposes, although cuttings are sometimes taken from field or container plants if the time for taking cuttings happens to coincide with the time for shaping the plants by pruning.

Figure 50. Cuttings of rhododendron being stuck in peat and expanded mica mixture in pressed peat pots. (Courtesy Conard-Pyle Co., West Grove, Penna.)

Figure 51. Cuttings of Wiltoni juniper are taken in late fall or early winter. (Courtesy Conard-Pyle Co., West Grove, Penna.)

Hardwood cuttings of some

easily-rooted deciduous trees and shrubs, such as forsythia may be stored in bundles in moist sand or peat over winter at 30 to 35°F. During this storage the cut ends heal (form "callus"). In early spring they are lined out in the field (top end up!) or planted in beds or in containers. With adequate moisture they will form roots and then new shoots in the field.

Hardwood cuttings of such narrowleaved evergreens as yew, arborvitae, and juniper are taken late in the fall or early winter after the plants have been exposed to freezing weather. Leaves are removed from the basal portion of evergreen hardwood cuttings, just as they are for softwood and greenwood cuttings.

The procedure of placing cuttings into the propagation medium is referred to as "sticking." Using a wooden guide, so rows will be straight, a dull knife is used to make parallel slits in the medium about 2 to 3 inches apart across the bench. These slits are made about 3 inches deep. The cuttings are then inserted about 2 to 3 inches deep and from 1 to 3 inches apart in the slits. Roots will form only on the basal ends of the cuttings, so they must be stuck **top** end up! The medium is then firmed around them. A label with the name of the plant and the propagation date is inserted at the beginning of the first row of cuttings of each kind of plant. The cuttings in the bench are "read" from left to right and from front to back in the bench. The cuttings are usually thoroughly watered once by hand; thereafter, the misting system usually automatically takes care of the moisture requirements.

Some kinds of herbaceous perennials, such as garden phlox and oriental poppy, as well as a few woody plants are propagated from pieces of root about 2 inches long. These pieces are placed horizontally, about ½ inch deep in the propagation medium. These are called root cuttings. Under appropriate conditions, new shoots and roots form on them in a few weeks. Details on this method of propagation are given on pages 229, 230, and 302 in Reference 35. Plant Propagation Principles and Practices.

Grafting

Grafting requires the services of people highly skilled in this technique. It is the most expensive method of producing nursery plants.

It is used in special cases in which the plant will not come true from seed and also will not readily form roots from cuttings.

Grafting involves fastening pieces of 2 plants together so that they form a new plant. The desired cultivar forms the above-ground portion of the plant; while the below-ground portion of another plant forms the root system. "Koster" Colorado Blue Spruce, for example, will not come true from seeds and cannot be propagated from cuttings. It is grafted onto 2-year seedlings of Norway spruce. With appropriate handling, the two plant parts grow together to form a new plant that will grow to old age with a "Koster" Colorado Blue Spruce top and a Norway Spruce root system. The top part of a grafted plant is called the scion (or sometimes cion), while the bottom portion is called the understock (or sometimes stock). In grafting some kinds of plants, the understock may consist of a large piece of root, with no stem portion attached. Records of Chinese horticulture show that this technique was used as long ago as 2000 B.C. Grafting can only be done successfully with closely related plants; for example, flowering crabapples are grafted onto seedling apple rootstocks.

Grafting is usually done only with dormant plant material because moisture stress is low in that condition.

In grafting it is essential that the vascular tissues (phloem, cambium, xylem) of the cut pieces exactly match in a close smooth fit. The union takes place when new tissue (callus) develops and grows together to form new xylem, cambium, and phloem that is continuous through both parts of the plant. If the fit is poor, the union will be weak, grow poorly, and be very susceptible to breakage. After the pieces have been fitted together, they are tied with rubber strips or held together with grafting tape. The plant parts must be kept moist until after the new tissues have formed. This is done by keeping the grafts in a high relative humidity, under mist or in a propagation case, for several weeks. In the case of dormant deciduous grafts with bare-root understock, the completed grafts may be placed in moist material in cold storage. The union forms during storage and the grafts are lined out in the field in early spring in the same manner as some deciduous hardwood cuttings.

If the grafting is done outdoors, the cut surfaces are painted with grafting wax to keep them from drying until new tissues have formed. Grafting that is done outdoors is called "field grafting," while grafting that is done with potted or bare-root understock is called "bench grafting" because it is done at a work bench or table indoors.

A sharp knife is an essential tool in doing grafting. All cuts must be clean and smooth. A sharp knife is safer than a dull one because it is less likely to slip on the material being cut.

A number of types of grafts are commonly used by nurserymen. Among them are the whip (or tongue), splice, and side-veneer grafts. T-budding, which will be described later, is a special kind of grafting.

Figure 52. Whip graft surfaces must fit smoothly and tightly.

The whip graft is usually used for grafting apples, crabapples, and lilacs onto seedling understock or root pieces used as understock. The scion piece is prepared by making a long, slanting cut on the basal end. A vertical upward cut about ½ inch long is then made, starting about 1/3 of the distance from the pointed end of the slanting surface. The top end of the understock (which was planted in pots 2 weeks earlier) is prepared in the same way. The two pieces are then fitted together as shown in Figure 52. The fitted pieces are then tied with a rubber strip or wrapped firmly with grafting tape to hold them in place. The potted grafts are then placed under intermittent mist for several weeks. In the case of root grafts, they are usually wrapped in moist sphagnum moss and overwrapped with polyethylene film to keep them moist, and they are placed in 40°F storage until early spring when they are lined out in the field.

Splice grafting is the same as whip grafting except that the vertical cuts are omitted and the slanting surfaces are simply placed together, with the cambium tissues coinciding, and they are tied or wrapped

in the same manner as a whip graft. The splice graft is used for plants having stems that are too inflexible for whip grafting.

A side-veneer graft is commonly used for the propagation of cultivars of juniper, spruce, pine, cryptomeria, and rhododendron. As illustrated in Figure 53, a long, inward slanting cut is made in the side of the stem of the understock (a potted, 1 to 2-year old seedling). The loose bark piece is then removed with a second, short, downward cut at the bottom of the first cut. The stem of the scion piece is then cut

Figure 53. Side-veneer graft of 'Lobbi' cryptomeria on Cryptomeria japonica understock.

Figure 54. Side-veneer graft of 'Lobbi' cryptomeria, top growth of understock removed.

to fit exactly the prepared understock section. The two are placed firmly together and tied or taped. These potted grafts are then placed under intermittent mist for about 4 weeks. At the end of that time the callus tissue has formed, and the production of new vascular connections is underway. The top part of the understock, which was left in place during the healing period, is then removed, either all at once or in stages. This stimulates growth of the scion.

T-Budding

T-budding is a special form of grafting in which a single vegetative (leaf-rather than flower-producing) bud, together with a small piece of bark, is inserted under the bark of young understock plants. T-budding is more rapidly done than other forms of grafting; it gives a strong

union, rapid growth, and the percentage of "take" is often higher. It can only be done while the cambium is very active and the bark "slips" easily. T-budding is used for the commercial production of garden roses, many kinds of fruit trees, nut trees, and patented shade tree cultivars.

A special grafting knife, called a "budding" knife is used for this work. This knife is unusual in having a special projection for lifting flaps of bark on the side of the understock stem while the bud piece is being inserted.

Figure 55. Top, budding knife; bottom, grafting knife.

Figure 56. T-budding; shield-shaped scion piece with bud is inserted under flaps of T cut bark of understock.

The understocks for budding are commonly seedlings closely related to the scion species. Rooted cuttings are also often used as understock in budding. The understock has been grown in the field for 1 or 2 years prior to budding. Budding is usually performed in the field. Fruit tree budding is usually done in early spring or late summer; shade trees are usually budded in late summer; garden roses are usually budded in July and August in the Northeastern States.

T-budding involves making a T-shaped cut in the bark of the understock near the soil line. This cut is made on the north side of the plant to prevent the sun from drying the tissues. A vegetative bud of the scion is removed from a "budding stick" by cutting off a shield-

shaped piece of bark surrounding the bud. These budding sticks are vigorous branches from the selected cultivar. The leaves have been cut from these stems to leave a petiole stub at each node. These budding sticks are usually carried in clean, moist burlap to keep them in fresh condition. Each bud must be carefully cut from the stick just prior to insertion. It is handled by the petiole stub to avoid contamination of the cut surfaces. The flaps of the T cut are lifted with the special projection on the knife, and the bark piece with the bud is carefully inserted to make a tight fit. The final position of the parts are indicated in Figure 56. A rubber strip is then wrapped snugly around the stem to hold the bark of the understock in close contact with the bud piece. The buds require 2 to 3 weeks to "take." At that time they should show signs of enlarging. A bud that has not enlarged and has blackened is dead. The foliage growth of the understock is usually allowed to remain on the plant through the rest of the growing season in which the budding was done. This top is pruned off early the following spring, the cut being made just above the bud that was inserted the previous summer. The budded plants are usually grown for two more seasons before they are ready to be sold.

In the production of garden roses in California and Texas, the understock shoots are removed when the bud has "taken," and the season is long enough for considerable scion growth in the same season. These plants are usually dug and marketed at the end of the following season.

Layering

Two types of layering --simple layering, and mound layering -- are used for the commercial production of certain plants.

Simple layering is used for certain rhododendron and magnolia cultivars that cannot be commercially reproduced by any other method. Simple layering consists of bending a branch of the parent plant into a U shape, with the bottom of the U held under

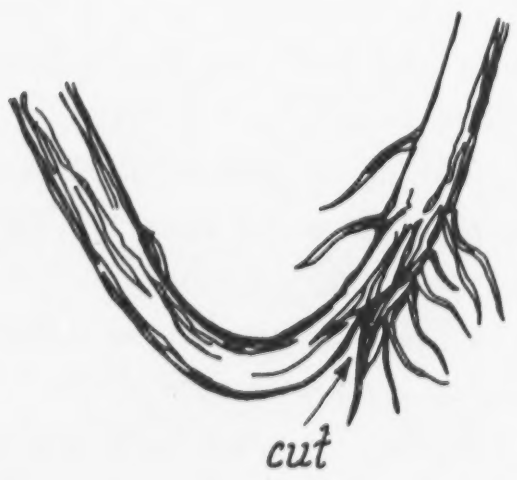


Figure 57. In simple layering the stem is notched and bent under the soil surface.

the soil surface by means of a metal or wooden hook. To stimulate root formation, a notch or cut is usually made about 1/3 of the distance through the stem at the lowest point. A root-promoting substance applied to this cut surface usually speeds root formation. The soil must be kept evenly moist while rooting takes place. The new plant may be severed from the parent plant the season after layering and moved to a nursery row for further growth to saleable size. The number of new plants that can be produced by this method is limited to the number of branches in the parent plant that can be placed in the appropriate position. This is a costly way to produce a limited quantity of new plants, but in certain instances it is the only way that new plants of certain cultivars can be obtained.

Mound (or stool) layering consists of cutting an established parent plant to the ground during the dormant season and mounding soil around the base of the new shoots as they develop from the stubs in spring. The soil cover causes etiolation (bleaching of the chlorophyl) in the base of these shoots, which encourages the formation of roots near the base of the shoots. These rooted shoots are removed from the parent plant the following spring, and lined out in the nursery field for growing to marketable size. This technique is used for the propagation of certain apple clones, dwarfing understock for apples, Mazzard cherry understock, and several bush fruits.

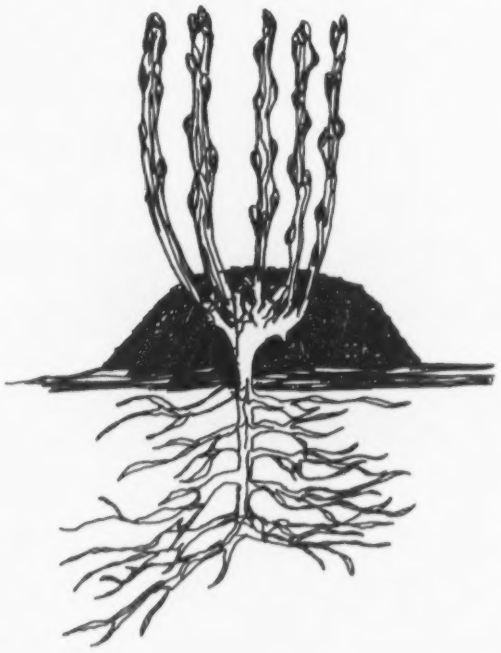


Figure 58. Propagation by mound layering.

Division

Division is used commercially for the propagation of plants that have a clump (or crown) growth habit. Although some woody plants have this habit, this method is used almost exclusively for certain herbaceous perennials. Peony and Shasta daisy are divided in the fall; daylily and gardent phlox in spring or fall; iris and oriental poppy in midsummer after flowering.

The technique of dividing a plant consists simply of lifting the clump with a spading fork (to save as many roots as possible), placing the clump on its side, and cutting the clump vertically into smaller pieces with a sharp spade. Each section has top growth and roots, and is replanted in the nursery to grow to saleable size. Clumps of some kinds of plants, such as those of oriental poppy, after being lifted, are easily separated into smaller sections by hand.

Seed Propagation

Propagation by seed is nature's most common method of reproducing plants. Seed propagation is used commercially for many woody plants that produce seedlings that are nearly identical with the parent plant.

Seed Sources

Seed for the propagation of nursery plants may be purchased from wholesale seed dealers, or they may be collected. Probably most nursery propagators obtain seeds from both sources.

Some nurseries maintain plantings of selected trees and shrubs which they use as seed sources because of the superior seedlings which they produce. Sometimes they obtain permission to collect seeds from appropriate specimens on private or publicly owned land.

Collected Seed

If seed is to be collected locally, the time of collection is important. The ripening seed must be observed every few days near the end of the ripening period. It should be collected when fully ripe, but before it falls. Often there are only a few days between these two events. The seeds of certain species within the rose family germinate at once if collected before they are fully ripe, and if they are sown at once. This is an unusual case because fully ripened seeds of the same species require months of cold, moist conditions (stratification) before they will germinate. It is important that the seed be properly labeled at the site of collection to avoid the risk of losing the identity of a particular lot of seed. The site and date are often recorded along with the complete technical name of the plant. A propagator often keeps a log book of seed collections

Figure 59. Nurseries often collect, clean, and store their own seed. Ginkgo seeds at the top; barberry seeds, lower left.

so that he can trace the source of particularly good or poor lots of seedlings.

Dry types of seeds are usually cleaned by sifting them through screens of appropriate weaves to retain or pass the seeds while removing chaff and unwanted material.

Pulpy fruits are often allowed to ferment in water for several days or weeks to loosen the pulp, which is then removed by rubbing the fruits through screens of appropriate weave to hold back the seeds. This can be an unpleasant task with certain kinds that develop very obnoxious odors.

After the seed is thoroughly air dried, most kinds are placed in air-tight labeled containers (usually glass jars) and stored in the dark at a temperature between 35° and 40°F. Properly stored seed often keeps its viability for several to many years. Seeds of some plants, red maple for example, will germinate as soon as they are ripe, and are produced early enough in the season so sturdy seedlings can develop from them before fall. Ripe seeds of others, such as rose, pin oak, and white pine require 3 to 6 months of stratification before they are sown. Failure to satisfy this requirement is likely to result in no germination at all. It is very difficult to guess what the storage and germination requirements may be for seeds of a particular plant, because the seeds of even very closely related plants may have very different requirements. Hard seed coats of some kinds must be chipped or sanded before they can absorb the water needed for germination. This operation is called "scarification."

Fortunately, these requirements for most kinds of plants commonly grown from seed are given on pages 561 through 685 in Reference 35, Plant Propagation Principles and Practices. You may wish to use this reference before propagating some woody plants from seed.

Seed Propagation in the Greenhouse

Fine seeds, such as those of rhododendron, azalea, and mountain laurel are usually germinated under greenhouse conditions because of their precise moisture and light requirements. These three also require an acid soil for growth.

A steamed soil mixture, usually a 2-1-1 by volume mixture of peat, sand, and loam soil, is used in flats or shallow pots. The surface is smoothed. The seeds are either broadcast over the surface or planted in shallow grooves made in the surface of the medium. Sphagnum moss is then applied evenly over the seeds by rubbing it through a fine screen. It is put on just deeply enough to cover the seeds. The containers are then labeled and placed in a greenhouse. Because the seeds are so fine that they may be easily moved out of place when watered overhead, the containers are usually watered by immersing them in water at a depth such that the water surface is about ½ inch below the level of the soil surface in the container. The time intervals for watering them are important - if the germinating seeds dry too much even once, it is fatal. On the other hand, if they are kept too wet, the tiny roots will die from lack of oxygen. After the seeds have germinated, which usually takes several weeks, the containers are kept in a humid, shaded greenhouse. These seedlings grow slowly and are transplanted at a wider spacing in flats after several months. They may be placed in shaded coldframes, where they are wintered before being planted in beds.

Figure 60. Medium size seeds are sometimes started in greenhouses.

Medium size seeds of some kinds of plants are also handled under greenhouse conditions if they have requirements for germination that are difficult to fulfill under outdoor conditions.

Seed Propagation Outdoors

A well-drained, fertile, medium-textured loam soil is preferred for propagating seeds. The pH of the soil will depend upon the species of seed sown. Generally, a pH of 6.0 to 6.5 is satisfactory for most nursery plants.

One and one-half years are needed to prepare an adequate seed bed for sowing seed. The preparation procedures are as follows:

1. In the fall, plow, disc, and plant a cover crop of ryegrass.
2. The following spring, plow, disc, and plant a green manure crop of soybeans.
3. The following fall, plow, disc, and plant a cover crop of ryegrass.
4. The following spring, plow, disc, and prepare for sowing seed. Enough time should be allowed for the cover crop to decompose before sowing seed. For a shorter preparation period or for fall sowing, adjustments can be made in the above procedures by starting with stages, 2, 3, or 4.

Figure 61. A sudex green manure crop will be plowed under before nursery seeds are sown in beds in fall.

Large seeds, such as those of peaches, apricots, and walnuts, are commonly planted 12 inches apart in rows spaced 3 to 4 feet apart in the field. They are planted by hand.

Medium size seeds of some plants, Rosa rugosa for example, may be sown in rows. However, medium and small sized seeds are usually sown in long seed beds. These beds are about 4 feet wide with aisles of 2 feet between them. The seed beds are raised 6 inches above the aisle to facilitate drainage, which aids in preventing loss by damping-off, a fungus disease.

The seed bed should be treated with chemicals to destroy harmful insects, disease organisms, and weed seeds. Some of these chemicals are extremely dangerous and must be applied with care.

Seeds are generally planted in either fall or spring. Before seeds are sown, they should be tested for germination percentage, because this determines the seeding rate. The test results include percent purity, number per pound, and percent germination.

The rate of sowing depends upon the number of plants desired, the size of the seed and the quality of the seed. A formula given on page 178 in Reference 35. Plant Propagation Principles and Practices, can be used to determine the amount of seeds required.

Seeds are often sown by hand. If large quantities are involved, and a seed sowing machine is used, it should be

Figure 62. Seed sowing machines are used if large quantities are involved.

Figure 63. Seeds of Rugosa Rose being sown in rows in late October.

carefully calibrated. This may be done by placing a quantity of seed in the seeder and passing the machine over a measured area of clean floor. The seed is then swept up and weighed. From the weight of the seed distributed over the measured area, one may calculate the rate of application the machine has delivered. If this rate is higher, or lower, than the desired rate, the machine should be adjusted, and the delivery rate determined by the above method. Several such "trial and error" tests and adjustments may have to be made before the machine has been adjusted to give the desired delivery rate.

Figure 64. Field-sown seed is often covered with sand rather than soil.

Figure 65. Water-powered mechanism for rotating an overhead irrigation line.

After the seed has been sown, it is lightly covered with soil or sand. The seed beds must be kept moist from the time the seed is sown through the time that germination takes place and until the seedling plants have developed roots several inches long. Rainfall may have to be supplemented with sprinkler irrigation to fulfill this requirement. Seeds sown in the fall may be attractive to rodents and birds, and control measures may have to be used to prevent losses. Lath shade is required for seedlings of most narrowleaved and broadleaved evergreens and a few deciduous woody plants. Although this shade can be removed from most of them once the seedlings are well established, most broadleaved evergreens require

Table 10. Propagation methods for woody ornamental plants recommended for a school nursery.

STANDARD DECIDUOUS TREES

Sugar Maple - seed
Red Maple - seed
"Marshall Seedless"Ash - T budding
"Shademaster" Moraine Locust - T budding
Red Oak - seed
Pin Oak - seed
"Greenspire" Littleleaf Linden - T budding

SMALL DECIDUOUS TREES

Japanese Maple - seed; T budding
Eastern Redbud - seed
Flowering Dogwood - greenwood cuttings or seed
Washington Hawthorn - T budding
Saucer Magnolia - softwood cuttings
Carmine Crabapple - T budding (fall) or seed
Kwansan Cherry - T budded (July or August)

EVERGREEN TREES

White Fir - seed
American Holly - semi-hardwood
Southern Magnolia - cultivar-sidegraft onto Mag.s. seedling
Norway Spruce - seed
'Koster' Blue Spruce - side or veneer graft
White Pine - seed
Canada Hemlock - seed

NARROWLEAF EVERGREEN SHRUBS

Pfitzer Juniper - winter cuttings
Andora Juniper - winter cuttings
Mugho Pine - side veneer graft
'Brown' Japanese Yew - winter cuttings
'Hick's' Yew - winter cuttings
'Ware's'Arborvitae - winter cuttings

MEDIUM DECIDUOUS SHRUBS

Snowflake Deutzia - softwood or hardwood cuttings
Dwarf Winged Euonymus - hardwood cuttings
Bridalwreath Spirea - softwood cuttings
Persian Lilac - seeds
Fragrant Viburnum - softwood cuttings
Linden Viburnum - seeds
'Bristol Ruby' Wiegela - softwood or hardwood cuttings

SMALL DECIDUOUS SHRUBS

Rockspray Cotoneaster - softwood cuttings
Dwarf Flowering Almond - T budding
'Anthony Waterer' Spirea - softwood cuttings
Dwarf Cranberrybush Viburnum - softwood cuttings

LARGE DECIDUOUS SHRUBS

Purple Smoke Bush - softwood cuttings
Shrub Althea - softwood or hardwood cuttings
Beautybush - softwood or hardwood cuttings
Amur Privet - seed; softwood or hardwood cuttings
Hybrid Lilac - softwood cuttings in early June
Siebold Viburnum - softwood cuttings

DECIDUOUS AND EVERGREEN VINES AND GROUND COVERS

American Bittersweet - seeds; softwood orchardwood cuttings
Clematis - greenwood cuttings
English Ivy - softwood cuttings
Japanese Wisteria - softwood or hardwood cuttings
Carpet Bugle - division, (spring or fall)
Creeping Juniper - winter cuttings
Japanese Spurge - cuttings
Myrtle, or Periwinkle - cuttings
Purple-leaf Wintercreeper - softwood cuttings

Note: Technical names for these plants are given in Appendix A, p. 203. Detailed propagation instructions for mostof these plants are given in Reference 35, Plant Propagation Principles and Practices, p.p. 618-684.

shade for the entire first growing season (and possibly second).

Propagation Methods for Specific Plants

The appropriate propagation method varies considerably with the particular plant involved. Sometimes more than one method is successful- then the economics of production determine which method is used in commercial propagation. Table 6 page 98, gives the commercially used methods of propagating certain woody ornamental plants that have been suggested for a school nursery in Appendix A, Because seed of a particular plant may require stratification while another may not, and because a particular grafting or budding technique may be required for successful propagation of a certain cultivar, it is suggested that Reference 35, Plant Propagation Principles and Practices be consulted before an unfamiliar plant is propagated.

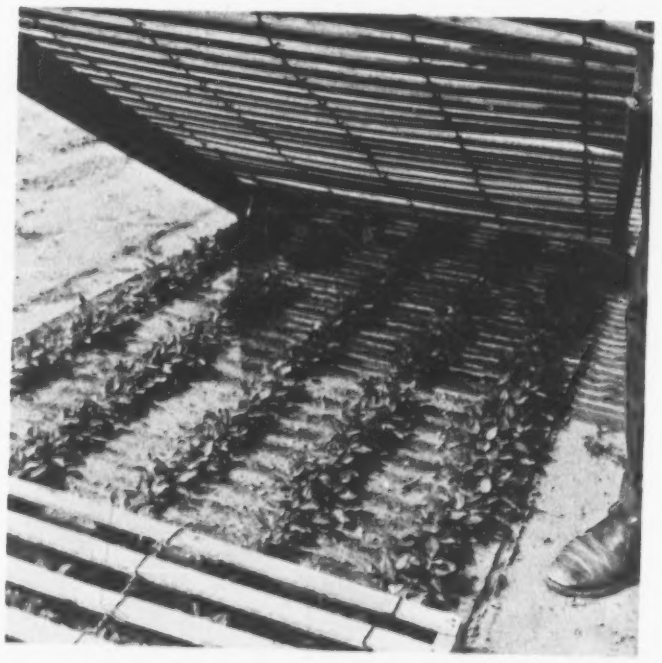


Figure 66. Seedlings of Oregon Grapeholly are germinated and grown 1 year under lath shade.

Figure 67. Sweetgum plants in seedling bed, August of the second year.

Care of Rooted Cuttings, Grafts, and Seedlings

Softwood and greenwood cuttings that have been rooted in flats are moved to outdoor frames where they are usually shaded for several days

Figure 68. Flats of rooted cuttings of forsythia in a coldframe.

Figure 69. Small narrowleaved evergreens in pots in a coldframe.

before exposure to full sunlight. They are watered and fertilized appropriately that season and are wintered in the frame. Early the following spring, before growth has started, these plants are lined out in rows in the field, or they are planted in containers for the production of container stock. The fact that the flats can be moved directly to the place where the plants will be planted is a great convenience. Similar cuttings that were rooted directly in the greenhouse benches are carefully lifted and transplanted into coldframes, where they are given the same care as those in flats. However, these small plants must be dug out of the frame in the spring for planting in the field or in containers.

Hardwood cuttings of needle evergreens and dormant deciduous plants, which develop shoots at the same time that roots are forming, are usually carried in the same greenhouse in which they were propagated, at reduced temperatures, until they can be moved to beds or frames in early spring. Hardwood rooted cuttings of evergreens may remain in shaded beds for several years before being lined out in the field. Hardwood cuttings of some vigorous deciduous plants, such as forsythia and privet, may be

made in December, held in cold storage and planted in early spring as described on page 109. If shoots have started to elongate before these stored cuttings are planted, they will die in the field.

Grafted plants that are well knitted are handled according to the method used for producing them. Evergreens in which the understock was started in pots in the greenhouse are carried in the greenhouse until the scion is growing well. They are then planted into outdoor beds or frames that are shaded. Deciduous grafts of a similar nature may be placed in a coldframe under lath shade for a few days. After a week or two of exposure to full sunlight, they are taken from the frames and lined out in the field. Plants grafted in the dormant condition and placed in storage for knitting are usually lined out in the field in early spring before growth starts. Since budding is nearly always done on rootstock that is already established in the field, the resulting plants are usually grown to marketable size where they were budded.

Seedlings of seed sown directly in the field are generally grown to marketable size in that position. Such plants are often intended as understock for budding, which is done in the field. Seedlings that were propagated in seed beds are grown in that position for a year or two, depending upon the growth rate of the plant. Deciduous seedlings are often lifted in the fall and stored for grafting understock, or lining out in early spring, or for planting in containers. Seedlings of broadleaved evergreens and certain deciduous plants may be grown in the seed beds for 2 years under lath shade, before being lined out in the field. Seedlings of narrowleaved evergreens are generally grown in the seed beds for 2 years. In the fall of the second year they may be dug and potted to serve as grafting understock. Narrowleaved evergreen seedlings to be lined out in the field or to be grown as container plants are usually transplanted in early spring.

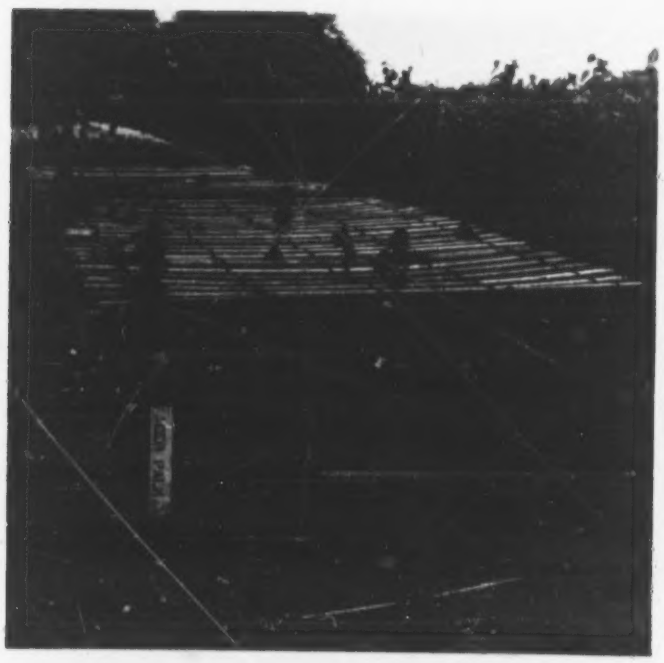


Figure 70. Seedlings of Japanese maple being grown in a lath-shaded bed for 2 years before being lined out in the field.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

The propagation of nursery stock requires knowledge and skill which comes largely through experience. The school greenhouse, sashhouse, and/or hotbeds and coldframes are useful facilities for providing experience in propagation techniques used in the nursery industry. However, tours of larger propagation businesses will help students develop their concept of the size and scope of this segment of the nursery industry.

The teacher needs considerable experience to teach this unit. He must know when to take cuttings, how to prepare a rooting mixture, how to prepare and "stick" the cuttings, and how to care for the cuttings during the rooting period.

Layering is an easy propagating technique to learn. Success with grafting and budding requires skill, practice, and careful attention to detail. Growing nursery stock from seed requires knowledge of the specific requirements of the plant involved. Since experience is the best teacher, there is no better way to prepare to teach the subject than to practice the skills required in plant propagation.

References

Plant Propagation Principles and Practices, Second Edition, Englewood Cliffs, Hartman, H. T. and D. E. Kester, Prentice-Hall, Inc., NJ, 1968.

Producing Better Transplants, Tech. Bul. No. 120. Jiffy Products of America, West Chicago, IL, 1970.

The Grafter's Handbook, Garner, R. J., Oxford University Press, Fair Lawn, NJ, 1958.

Audio-Visual Aids

"Commonly Used Trees, Shrubs and Ground Covers", a series of 2 x 2 inch slides, Shelly, Christopher H., Department of Agricultural Education, The Pennsylvania State University, University Park, PA 16802, (52 slides for $9.00).

"Budding and Grafting", sound filmstrip, 61 frames 198-1, $7.50; additional scripts, 198-2, 50¢. Voc. Ed. Productions, Calif. State Polytechnic College, San Luis Obispo, CA 93401.

Audio-Visual Aids (Continued)

Film Loops - (Nursery Management series), NM 3, Root Grafts, 4 min.; NM5, Conifer And Hardwood Cuttings, 4½ min. (Greenhouse Management series), GM 1 Seeding, 4½ min.; GM 4, Softwood Cuttings, 3 min. $22.00 each. Pace Production, Inc. 4447 North Victoria, New Bringhton, MN 55112.

Supplies

Peat moss and sharp sand or perlite
Root promoting compound
Grafting twine, strips or tape
Grafting wax
Nitrogen fertilizer and a complete fertilizer with a ratio of 2-1-1
1-2-1
Insecticides, fungicides
Burlap
Pruning equipment
Stakes, #10 wire
Garden hose
Seeds
Grafting and budding knives
Labels
Flats
Pots 2½", 3"

Suggested Learning Activities

1. Each student should be taught how to sharpen a grafting or budding knife properly.
   a. An oiled whetstone should be used; a carborundum stone removes metal too quickly.
   b. The blade should be held at a 20° angle to the stone, cutting edge forward, and drawn smoothly across the entire length of the stone. (If only a small part of the surface of the stone is used, a groove will be worn across it in a few weeks, rendering useless a stone that would, if properly used, wear evenly and last for many years.)

Suggested Learning Activities (Continued)

c. Step (b) is repeated on both sides of the blade until it is smooth and sharp.
d. The sharpness can be tested by slashing the edge of a piece of paper. Test the full length of the blade.
e. To get a fine edge the blade should be stropped on a leather strop. This is done by holding the blade at a 20^{o} angle with the back of the knife forward (cutting edge trailing).
f. A knife with a fine edge should be capable of smoothly shaving hair from an arm.

2. Students should learn how to propagate different types of nursery stock growing in the school nursery. The following plant may be used for propagating different types of cuttings:
   a. Softwood Cuttings
      1. Cotoneaster
      2. Spirea
      3. Weigela
   b. Hardwood Cuttings
      1. Japanese Yew
      2. Amur Privet
      3. Winged Euonymus
   c. Greenwood Cuttings
      1. Flowering Dogwood
      2. Hybrid Lilac
3. Have students work out a propagation time schedule for crops in the school nursery.
4. Have each student collect, clean and store seeds of woody ornamentals.
5. Have students sow fine seeds properly in the greenhouse.
6. Have students sow medium-size seeds of woody ornamentals in outdoor beds.

7. Have students sow large seeds of woody ornamentals in a nursery row.
8. Have students make whip grafts of flowering crabapples. Seedling apple understock can be purchased for this purpose. Scion wood is usually collected locally.
9. Have students do veneer grafting of junipers.
10. Have students do T budding of garden roses. Rosa multiflora understock will have to be started in the school nursery the year prior to budding.
11. Arrange class trips to a local nursery to observe propagators in late October when collecting seeds, in December when grafting plants, and in April when sowing seeds.

Suggested Placement Activities

1. Arrange for interested students to get work experience in propagation with a wholesale nursery firm.

Test

1. Ornamental plants are propagated from seeds and vegetatively. Name three important advantages of vegetative propagation.
2. Root formation on hardwood cuttings is aided by what operation?
3. Name two methods of sexual reproduction.
4. Softwood cuttings are taken from what season's growth?
5. Name two plants that are propagated from hardwood cuttings.
6. What time of year are hardwood cuttings taken from narrow-leaved evergreens?
7. What is the top part of a graft called?
8. Cuttings in propagation beds root faster under what temperature condition?
9. What fertilizer ratios are used when fertilizing very young woody ornamentals?

10. Name three common types of grafts used in propagating nursery stock.
11. What is the scarification process?
12. In grafting plants, why is it very important that the cambium layers of the two parts make a perfect fit?
13. What term is used to describe the reproduction method whereby a branch or shoot on a growing plant is buried in soil to develop roots and start a new plant?
14. During what months are seeds collected?
15. During what month is grafting done?
16. Describe how garden roses are propagated by budding.
17. What is the purpose of stratifying seeds?

CHAPTER 6

GROWING NURSERY STOCK IN THE FIELD

Learning Objectives

1. To understand how soils are prepared and modified for planting trees and shrubs in the nursery.
2. To be able to bed and line out nursery stock properly.
3. To know how to hold plants for short periods before they are planted.
4. To be able to dig and transplant bare-root stock as well as balled and burlapped stock.
5. To learn how to fertilize nursery stock properly.
6. To know how to control weeds in the nursery.
7. To be able to prune nursery stock properly.
8. To recognize and be able to control insects and diseases in the nursery.
9. To understand how to protect nursery stock during winter.
10. To become familiar with the cultural techniques for crops of trees, small trees, deciduous and evergreen shrubs, roses, perennials, vines and ground covers.

Key Questions

1. Why is crop rotation necessary in a nursery?
2. What does "lining out" mean?
3. In what condition should soil be at the time of cultivation?
4. How are clay and sand soils modified before nursery stock is transplanted into them?
5. How are weeds controlled in the nursery?
6. What are the purposes of top pruning and root pruning trees and shrubs?
7. What is the proper procedure for transplanting bare-root stock is Balled and burlapped nursery stock?
8. Why and how are trees sometimes tied to stakes?
9. How is nursery stock protected from winter injury?

Key Words

Aerate - cause air to circulate through

B&B - balled and burlapped

Crop rotation - growing different crops in succession on the same piece of land

Defoliation - dropping or shedding of the leaves of plants

Friable soil - soil that is easily crumbled or crushed

Fungicide - any substance used to kill fungi or prevent the growth of spores (often loosely used to refer to any disease control material)

Granule - small grain-like particle

Leach - dissolved and washed away in the soil

Legumes - plants belonging to the pea family with seeds enclosed in pods; the roots have nodules that contain nitrogen fixing bacteria

Lining out - transplanting nursery stock into rows in the field

Perennial - having a life cycle of more than 2 years

Pruning - the removal of dead or living plant parts to improve the health, safety, or the shape of the plant

Shingletow - long, thin wood shavings

Growing Nursery Stock in the Field

Producing nursery stock for landscaping, conservation, reforestation, and orchards takes from 2 to 6 years from the date of propagation, depending upon the kind of plant involved, until the plants are sold. Trees 15 feet tall may require 15 or more years in the nursery to reach this size. The semi-skilled workers in a nursery need to know the cultural requirements of growing nursery stock so that they can help to produce high quality material efficiently.

Technical information on how to modify the soil for nursery stock, on methods of propagation, digging, lining out, heeling-in, transplanting, pruning, fertilizing, controlling pests and diseases, and other similar operations in the nursery are important to the success of a nursery business. A person with the knowledge and ability to carry out these tasks, and who does them well, is likely to be asked to accept positions having greater responsibility.

Crop Rotation Plans

The rotation of field-grown nursery crops is somewhat more complicated than rotations for farm crops or greenhouse crops because some nursery crops require 2 years to reach marketable size, while others require 7 or more years.

In order for the nursery to have an annual supply of standard trees, sugar maples for example, a crop of them must be planted each year so that sugar maples will be ready for marketing 7 years later. In other words, if the nursery is to market 200 sugar maples each year, it must plant 200 trees each year over every 7-year period. (Actually, it would plant 230 to 250 to allow for losses from numerous causes.) In any one year, then, the nursery is growing 1400 sugar maples. It also has space, for 200 or 400 more sugar maples, that is planted to a green manure crop for 1 or 2 years for soil improvement. Similar planning must be done for each kind of plant grown in the nursery.

Table 7, gives the spacing and the numbers of years to reach marketable size for the groups of nursery stock. For examples of specific plants within these groups, see Appendix A, page 203.

Cover crops or green manure crops are rotated with nursery crop plants in order to replace at least a portion of the organic matter that was lost in producing the nursery crop. A high organic matter content results in better crop growth due to improved aeration, moisture holding capacity, and nutrient reserves.

Figure 71. Red maples require 5 to 8 foot spacing between rows (Courtesy Princeton Nurseries, Princeton, NJ).

A cover crop of a grass sod, or a mixture of grasses and clover is normally planted in the spring following a fall-dug nursery crop. It is fertilized well, and is grown for 1 to 3 years before being turned under in the spring prior to the planting of another nursery crop.

A green manure crop rotation may be used to improve the soil in 1 year. Usually field corn, a sorgum sudan cross, or soybeans are planted in the spring. They are plowed under in August and the field is then planted with rye or winter wheat, which is plowed under the following spring, prior to planting a nursery crop. To protect young nursery stock from being "heaved," (lifted out by freezing of the soil during winter) a companion crop of oats may be sown after the last fall cultivation. The oats are plowed under in the spaces between rows the following spring.

Table 7. Space and cropping time required by groups of nursery stock.

Group	Spacing		Years
	Between Rows	In Rows	
Standard deciduous trees	3½-5 ft	18 in	2
	3½-5 ft	36-48 in	7
	8 ft	8 ft	over 1½ in caliper
Small deciduous trees	3½-4 ft	18 in	2-3
	3½-4 ft	36-48 in	4-6
Evergreen Trees	4 ft	2-2½ ft	6
Deciduous shrubs	3½-4 ft	12-24 in	3-4
Narrow-leaved evergreen shrubs	3½-4 ft	2-3 ft	5
Deciduous and evergreen vines and ground covers	4 ft	12 in	3
Perennial flowers	4 ft	12 in	1
Roses	3½-4 ft	8-12 in	2

Soil Preparation and Modification

The success of growing nursery stock depends to a great extent on the preparation of the soil for planting. Before plowing the soil, one must determine whether it is in the right condition for working. If a heavy clay soil is worked while it is too wet, clods will be created which cannot be broken up all season. On the other hand, if a clay soil is too dry, it becomes so hard that a plow cannot enter it. To determine if a clay soil is in the right condition for working, one should pick up a handful of soil and squeeze it between the thumb and fingers. If it becomes a mud pie, the soil is too wet, and if it crumbles into dust, it is too dry. When the soil can be lifted easily in one piece, yet crumbles like pie crust when a little pressure is exerted on it, it is time to cultivate the ground.

Loose, gritty or sandy soils can often be worked satisfactorily while fairly wet with no harmful effects. Cultivation is not merely loosening the soil. When plowing, each slice of soil is turned completely so that what was the top becomes the bottom. This helps distribute the organic materials at the surface all through the soil layer in which the roots of the nursery crop will grow.

Plowing of fields for nursery planting is often done in the fall for several reasons. It improves the physical condition of the land, permits greater decay of materials that are plowed in, allows earlier working and planting in the spring, and exposes insect pests and diseases to destruction through freezing. Fall plowing also reduces the spring work load which is usually very heavy.

Although many nurserymen use the moldboard plow ordinarily used in farming operations, many have found that the chisel plow gives better results. The chisel plow mixes the field debris or green manure crops all through the soil instead of depositing them in a layer at the bottom of the plowed layer. It should not be used if the cover crop is one with long branches, because these become tangled in the plow blades very quickly. Best results are obtained if the field is plowed a second time with the furrows at right angles to those of the first pass. A crawler tractor

Figure 72. A chisel plow mixes green manure crops all through the soil. (Courtesy the American Nurseryman, Chicago.)

is recommended to avoid soil compaction. A tractor of higher power is needed for chisel plowing than for moldboard plowing. Final soil preparation just before planting consists of discing or harrowing twice, the second pass at right angles to the first.

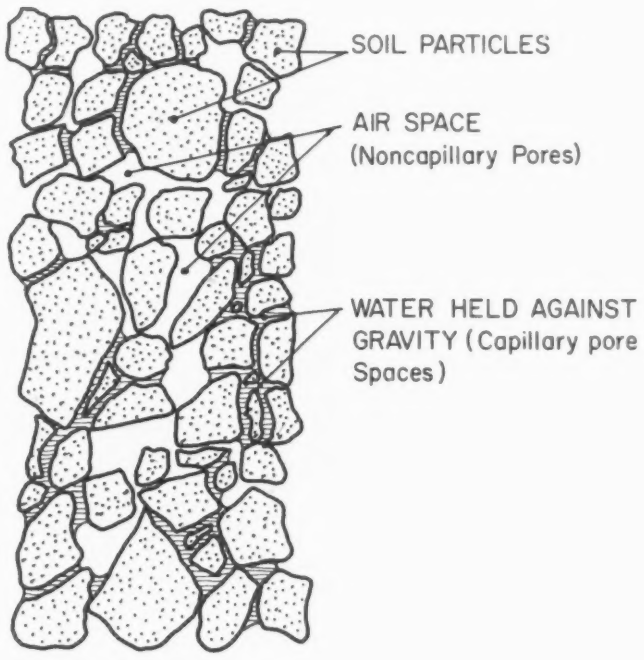


Figure 73. A soil having good structure.

Trees and shrubs grow best in soils that are granular and friable. If the soil structure is not friable, roots may not penetrate the soil normally. Good root development is important for transplanting survival. The ideal soil for root development has very small particles of silt and clay bound together into larger aggregates or granules which do not readily fall apart when wet. A soil of this type absorbs water quickly, is well aerated, promotes activity of soil microorganisms, and

retains adequate soil moisture and nutrients.

Heavy clay soils and light sandy soils need to be modified before nursery stock is planted in them. Heavy clay soils tend to compact which results in poor aeration. Incorporating about 2 inches of organic matter such as peat moss reduces the soil compaction. Heavy green manure crops serve the same purpose and are the least expensive way to add organic matter to a nursery soil. For this purpose, domestic rye may be sown in September and plowed under in April; sudan grass may be sown in April and plowed under in July or August.

Light soils tend to dry out rapidly,and some of the nutrients are easily leached from them by heavy rains. The addition of organic matter to light soils enables them to retain more nutrients and water.

As the organic matter decomposes, some of the nitrogen becomes temporarily unavailable to plants and may cause the leaves to turn yellow (chlorotic). If 2 inches of organic matter have been applied, 20 pounds of ammonium sulfate per 1000 square feet should be added before the organic material is incorporated into the soil. If a soil test indicates a need for other nutrients as well as nitrogen, they should also be incorporated at this time.

Bedding and Lining Out Nursery Stock

Nursery stock is transplanted from the propagation bed into well prepared transplant beds, coldframes or into the field. Provision should be made for irrigating the transplants within 30 minutes after planting. When nursery plants are lined-out in fields, they are often watered from tanks mounted on trucks. Large portable irrigation systems may be used for later watering. If the nursery plants are lined out in small transplant beds, a smaller perforated pipe irrigation system is often used.

Unrooted cuttings of dormant deciduous plants, such as forsythia, that have formed callus in cold storage, are lined out in the field in early April. They form roots in a few weeks, followed by shoot growth. Grafts of dormant deciduous trees, such as crabapples, are often handled in the same way as dormant unrooted cuttings.

Figure 74. Nursery stock being lined out in a bed.

Certain kinds of nursery stock, such as evergreens, are usually lined out in transplant beds or cold frames for growing the first year, rather than in fields. They are usually transferred to fields the following year. Slow-growing kinds may remain in the beds for 2 years Table 8 shows recommended spacing in beds for different types of plants. Spacings are given for transplanting the nursery stock into transplant beds, coldframes and fields.

If the nursery is on sloping land, care must be taken to arrange the rows across the slope, rather than down it, in order to keep erosion to a minimum.

Some large nurseries are testing a technique of rooting cuttings in flats and carrying the plants for the remainder of that season and through the winter in the flats. Careful attention to nutrition and moisture is needed. The following spring the flats are moved to the field, and the plants are lined out directly from them. This technique eliminates one transplanting operation.

Transplanting

After the seedling stage and 1 or 2 year transplant stage, the plants are ready to be moved into the fields in either spring or fall. The objective is to provide ideal conditions for rapid vigorous growth by providing sufficient space between plants, by providing adequate water and fertilizer, and by eliminating competition from weeds and pests.

Evergreen plants are transplanted from beds to the nursery field by hand with the use of lifting bars or spades, furrow plows and trowels, or

Table 8. Examples of recommended spacing for young nursery stock transplanted into transplant beds, coldframes, or fields.

Type of Plant	Propagated by	Being transplanted into	Recommended spacing Between rows	In the row	Examples
Narrow leaved evergreens	Seed	Beds	6" - 10"	3" - 6"	Hemlock
		Fields	3½' - 4'	4' - 5'	Red Pine
	Cuttings	Frames	6"	3"	Hicks Yew
		Fields	3½' - 4'	2' - 3'	Creeping Juniper
	Grafts	Frames	8"	4" - 6"	Koster Blue Spruce
		Fields	3½' - 4'	2' - 3'	Canaert Red Cedar
Deciduous	Seeds	Beds	8" - 12"	4" - 6"	Siebold Viburnum
		Fields	3½' - 4'	2' - 3'	Rosa rugosa
	Cuttings and Grafts	Fields	3½' - 4'	2' - 3'	Forsythia Crabapple
Broad leaved evergreens	Seed	Beds	4" - 10"	4" - 10"	Oregon Grape Holly
	Cuttings and Grafts	Frames	4" - 10"	4" - 10"	Wintergreen Barberry Hybrid Rhodo-dendron
	Seed Cuttings and Graft	Fields	3½' - 4'	2½' - 3'	Species Rhodo-dendron Laland Firethorn Hybrid Rhodo-dendron

with the use of transplanting machines. Usually, 1 to 2 rows of plants in the transplant beds are removed at one time. Two men may work together, one handling the lifting bar or spade, and the other lifting the plants from the loosened soil.

The furrows are made in the field at the desired spacing. Then the plants are distributed along the furrows while the planters, working on their knees, use trowels in setting the plants. During this process the transplants must be protected from drying as this will injure the roots of the plants.

Transplanting machines may also be used. They reduce the cost of operation and the effort involved. In order for the machine to work satisfactorily, the plants must be of uniform size.

Figure 75. A planting machine in operation. Note the drum for water.

The plant digger is a machine used in digging plants for further transplanting in the nursery. It cuts the roots and loosens the soil so that the plants may be removed easily. In moving the plants about the nursery, it is not necessary to wrap the roots in burlap as long as the soil clings to the roots. When a plant digger machine is not available to lift the plants, two men with spades may work together, on opposite sides of each plant.

Large plants may be transplanted by making a furrow deep enough to accommodate the full spread of the roots. The soil that is replaced around the roots should be pressed firmly.

Watering

In plants, the need for water is indicated by a slight wilting of the

leaves. On hot days this slight wilting may occur even if the soil is not deficient in moisture. Severe wilting causes scorching of the leaves and death of stems. If a plant is continuously deficient in water, the leaves will be small and the shoot growth will be very short.

A simple way to test for soil moisture in the field is to insert a spade into the soil and remove a spadeful of soil and check on how well the soil from the deepest point holds together. If it is so dry that it falls apart easily, the soil needs water. If it forms a firm ball when worked with the hands, then watering is not needed. In Northeastern States, nursery crops that have been in the field for more than one year usually do not require irrigation except during prolonged dry spells. Portable irrigation equipment is used on those unusual occasions when plants in the field must be watered.

Young nursery plants in seed beds and in transplant beds must be supplied with about 1 inch of water per week because of their shallow root systems. If this is not supplied by rain, it must be applied artificially. This is usually done by means of permanently installed rotating pipes with spray nozzles.

Whenever nursery plants are transplanted they must be thoroughly watered to firm the soil around the roots, to eliminate air pockets in the soil, and to make certain that the plant tissues are filled with water so that recovery from transplanting shcok will be rapid. During field planting, this water is often applied from a water tank mounted on a truck. Portable irrigation lines are also often used for this purpose.

Rhododendrons and other shallow rooted shrubs are usually mulched. A mulch reduces evaporation of moisture from the soil and maintains a cooler soil in warm weather. Mulches 2 inches thick also discourage weeds which remove nutrients and moisture needed by the crop plants. The most commonly used mulching material is peat. Other mulching materials that are satisfactory include: shredded bark, rice hulls, manures, and used (or "spent") mushroom compost.

Plants that produce only one flush of growth in a season, such as oaks, do not seem to have as high a moisture requirement as plants, such as mockorange, that produce new growth continuously. Narrowleaved evergreens, generally do not have as high a water requirement as broadleaved evergreens.

Fertilizing

Fertilizing nursery stock properly usually requires addition of organic matter, establishing and balancing the fertility level, and adjusting the pH.

Figure 76. A sod green manure crop being plowed under prior to planting a crop of rose plants. (Courtesy, Conard-Pyle Co., West Grove, Pa.)

Organic matter should be incorporated into the soil prior to planting. Green manure crops are usually plowed under for this purpose. Nurserymen use animal manures, if obtainable, at rates of 35 to 50 tons per acre. Green manure crops are most commonly used, including Sudan grass, field corn, and mixtures of grasses and clovers. Soybeans are also sometimes used for this purpose.

Before a field is planted, a representative soil sample should be taken and sent to a soil testing laboratory for analysis. An example of a questionnaire that accompanies the instructions for taking the soil sample is illustrated in Figure 77. The results returned by the testing laboratory are accompanied by fertilizer application recommendations, as illustrated in Figure 78.

After planting, the need for additional fertilizer should be based on soil tests made early each fall. The shoots of dwarf varieties grow 1 to 2 inches per year, while the shoots of vigorous tree types grow 8 to 12 inches per year, if adequate fertilizer levels are maintained. Some recent studies have shown that the greatest benefit from fertilizer application comes if the fertilizer is applied in autumn after the leaves have fallen from deciduous plants. At that time the tops are dormant, but the

THE PENNSYLVANIA STATE UNIVERSITY
SOIL TESTING LABORATORY, COLLEGE OF AGRICULTURE
UNIVERSITY PARK, PENNSYLVANIA 16802

PLEASE PRINT

LABORATORY NO.

SERIAL NO.

DATE

NAME

STREET OR R. D. NO. CITY ZIP CODE

PLEASE PRINT

NAME OF COMMERCIAL FIRM

STREET

CITY ZIP NO.

HOME GARDEN-ORNAMENTAL, FRUIT, FLOWER AND VEGETABLE INFORMATION SHEET (DO NOT USE THIS FORM FOR TURF OR COMMERCIAL CROPS)

COUNTY

SAMPLE NAME (NO MORE THAN 3 DIGITS)

HAS CROP BEEN PLANTED ☐ YES ☐ NO IF YES, DATE _____

CONDITION ☐ GOOD ☐ FAIR ☐ POOR

LIME

WAS LIME APPLIED WITHIN PAST 12 MONTHS? ☐ YES ☐ NO

POUNDS PER 100 SQ. FT. _____

VEGETABLE

☐ GENERAL VEGETABLE CROPS

FLOWER

☐ FLOWER BEDS ☐ ROSES ONLY ☐ GLADIOLUS ONLY

FRUIT

TREE FRUITS

☐ APPLES ☐ PEACHES ☐ PLUMS
☐ CHERRIES ☐ PEARS

SMALL FRUITS

☐ STRAWBERRIES ☐ GRAPES ☐ BUSH FRUITS

ORNAMENTAL

TREES, SHRUBS, GROUND COVER

PLEASE REFER TO BACK OF THIS SHEET AND FIND CODE NUMBER FOR TYPE OF TREE, SHRUB OR GROUND COVER. ENTER CODE NUMBER(S) IN THIS BOX

DO NOT WRITE NAMES

ARE TREES GROWN FOR CHRISTMAS TREES ☐ YES ☐ NO

Send this copy to laboratory with sample — Your report cannot be completed without this form — Keep Yellow Sheet.

Figure 77. Form to accompany a soil sample.

DATE	LAB NO.	SERIAL NO.	COUNTY	ACRES	FIELD	SOIL

• SOIL TEST REPORT FOR:

O. B. Joyful
Beetlebung Nursery
Celestial Terrace
Centre, PA

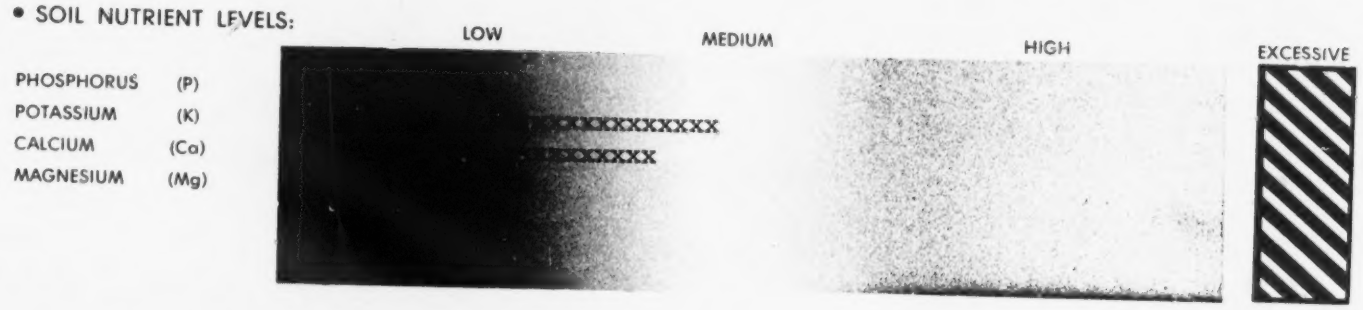
THE PENNSYLVANIA STATE UNIVERSITY
SOIL & FORAGE TESTING LABORATORY
COLLEGE OF AGRICULTURE
UNIVERSITY PARK, PENNSYLVANIA 16802

• LABORATORY RESULTS:

5.8	6.6	112	0.29	0.5	5.7	10.6	2.8	5.3	54.2
pH SOIL	pH BUFFER	P (lbs/A)	K	Mg (meq per 100 gm)	Ca	CEC	K	Mg % Saturation	Ca

OTHER:

• SOIL NUTRIENT LEVELS:



• **LIMESTONE AND FERTILIZER RECOMMENDATIONS FOR**

Recommendations for a crop of Japanese Yews:

Incorporate the following materials per each 100 sq. ft. of area:

5½ # of ground limestone to raise the said pH to 6.5
2 1/8 # of an 0-20-0 fertilizer or its equivalent.
1¼ # of a 5-10-10 fertilizer or its equivalent.
3¼ # of epsom salt or its magnesium equivalent.

Figure 78. Soil test results and recommendations for a nursery.

roots are active and capable of absorbing nutrients which may be stored within the plant until spring when they are used rapidly. Fertilizer is also often applied in early spring before growth has started. Midsummer applications on marginally hardy plants are avoided because they may encourage soft growth in late fall which is easily winter killed. A commonly used analysis is 10-10-10 (containing slow release nitrogen) which is applied at the rate of 20 lbs. per 1,000 square feet, or 870 lbs. per acre. There is some doubt that trees require anything more than nitrogen-carrying fertilizer for rapid growth. Inorganic forms of fertilizer are generally used because they are less costly per pound of active ingredient than are organic forms.

It may be necessary to adjust the soil acidity or alkalinity pH for certain nursery plants. Most nursery plants grow well in a soil having a pH within the range of 6.0 to 7.0. A pH of 7.0 is neutral. Some plants, such as rhododendrons and azaleas, require an acid soil within a pH range of 5.0 to 6.0. Ground limestone at 30 lbs. per 1,000 square feet, is used for making the soil more alkaline, (raise the pH); while sulfur at 10 lbs. per 1,000 square feet, is used for making the soil more acid (lower the pH). Applications of these materials may have to be repeated at monthly intervals until the desired pH is obtained. Certain nutritional disorders may affect the growth of the plants if the pH is too high. In such soils the following minerals may become unavailable to the plants: iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), and phosphorus (P). In soil that has a pH that is too low, calcium (Ca), magnesium (Ma), and potassium (K), are leached from the soil very readily; while phosphorus (P) and magnesium (Mg) may be converted to forms that are not available to the plants.

Pruning and Supporting

Nursery stock is pruned to induce compact growth and/or to develop a desirable form. Powered shears or hand shears are used.

When deciduous shrubs are lined out in the field, about 1/3 of the top is removed to induce the development of many more shoots near the base of the plant.

Narrowleaf evergreens that naturally have a rounded form are generally pruned in the same manner as deciduous shrubs when they are lined out in the field. Narrowleaf evergreens of upright form are permitted to develop a single main leader. Long lateral branches on both rounded and upright narrowleaf evergreens are "headed back" to strong side shoots to induce compact growth. This pruning is usually done before growth starts in early spring for taxus, juniper, and hemlock, and may be repeated in midsummer. Pines are pruned by pinching or cutting back the new shoots just after the new growth is completely extended between June 15 and July 15. The terminal leader should be pruned so that no more than 10 inches of current season growth remains. The side shoots should be pruned to 4 to 6 inches in length. Spruces and firs are usually pruned in late summer or fall.

Figure 79. Spruces are pruned in late summer, fall, or winter.

Broadleaf evergreens, such as rhododendron and azalea, are usually tip pruned immediately after flowering, to induce compact growth through the development of many branches.

Fruit trees and small flowering trees are pruned at the end of the first season to develop a main leader. This is done by removing side shoots. At the end of the second year, the tip of this leader is removed to cause the development of 3 to 5 main branches at 2 to 5 feet above the ground. This growth develops into the main structure which will have rounded form. In the case of fruit trees, this keeps the fruiting branches close to the ground for easy harvesting of the fruit.

Standard trees are developed with one main leader. Any secondary leaders that develop are pruned away so that weak crotches may be avoided.

Long side branches are "headed back" to induce symmetry in the plants. As the trees develop, excess side branches are removed so that those that are left are spaced about 12 to 18 inches apart.

Young trees of certain rapidly growing kinds, such as linden, oak, honeylocust, and some species of maple tend to develop whip-like main shoots that bend instead of growing straight. Straight trunks can be obtained by cutting the leader just above the ground and allowing a new leader to develop which is likely to be stronger and straighter. They may also be obtained by tying each main shoot to a stake. The stakes are driven into the soil on the prevailing wind side of the small trees so that the wind will not rub the tree against the stake and damage the bark. Wood, bamboo, or metal stakes are used. Raffia or soft twine is often used for tying, but special plastic ties are more quickly applied. The supports are usually removed at the end of 2 to 3 years. At the end of that time the leader will usually continue to grow straight. Grafted or budded trees are often given similar support for the same length of time to prevent strong winds from snapping off the shoots at the graft union.

Figure 80. Grafted Littleleaf Linden trees tied to bamboo stakes.

Figure 81. Patented black plastic ties hold shoots in place.

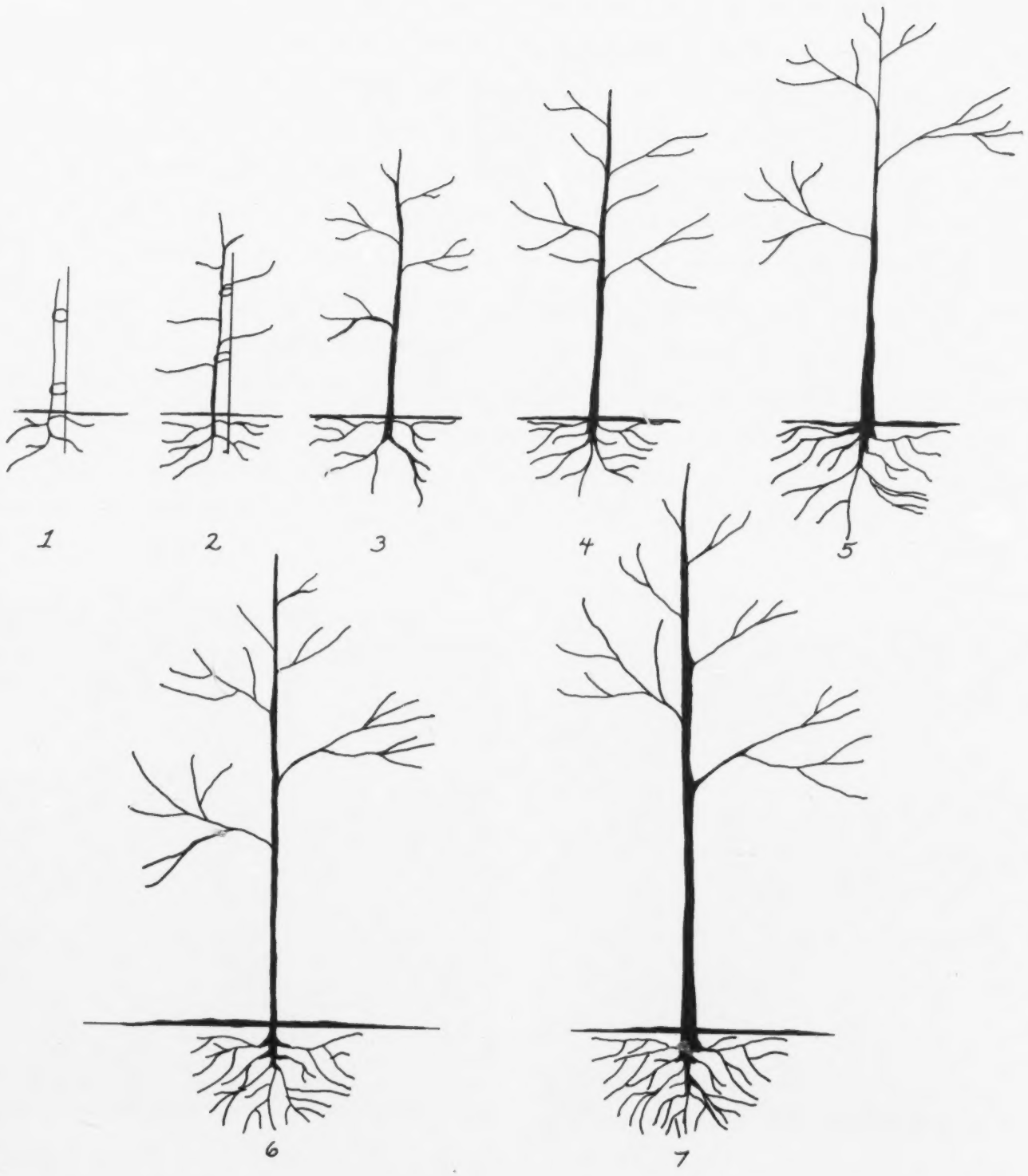


Figure 82. Growth of a deciduous nursery tree; each number stands for the end of a growing season; root pruned 4th and 6th season; lower limbs and excess branches removed each season.

Root Pruning

Root pruning is important for plants to be dug bare root as well as for those to be dug B&B. A properly root pruned plant will grow rapidly after it has been planted in its final location. The root systems of most kinds of trees and shrubs spread from 3 to 8 feet from the base of the plant. Since most soil balls are from 12 to 24 inches in diameter, unless something is done to confine the root system to the soil ball area, a considerable percentage of the roots will be lost when the plant is dug. This root loss can be a severe shock or even fatal to the plant. To overcome this problem the root system is pruned to confine it to the volume of soil that will be removed with the plant when it is dug. The pruning is done with a U-shaped blade (as shown in Figure 25, page 52) that is drawn under the plants by a tractor.

Root pruning should be done in the fall after the leaves of deciduous plants have fallen. New spring top growth can then adjust to the slightly restricted water intake capability of the pruned root system. Root pruning is done during the second year for rapidly growing shrubs, and every 2 to 3 years for most shrubs and trees.

Controlling Weeds, Insects, and Diseases

Weed Control

Weeds compete with crop plants for light, moisture, and nutrients. They may also maintain populations of insects and diseases that are harmful to the nursery plants.

Weeds may be controlled by cutting them off just under the soil surface (weekly cultivating), by soil fumigants, and by the application of granular or soluble weed killing compounds called herbicides.

Figure 83 . Machine cultivation is a major method for controlling weeds.

Machine cultivation is the major method for controlling weeds in the nursery. Each time the soil surface is stirred, the small weeds are destroyed, but the stirring also brings additional weed seeds to the soil surface where they germinate quickly. Cultivating between the rows of crop plants is often more economical than applying herbicides, particularly for certain very persistent weeds. Cultivation also serves to break up the crust at the soil surface, allowing water to penetrate the soil readily, thereby reducing the amount of water lost by surface runoff. However, the application of herbicides is often a more economical way to control weeds within the rows, particularly of plants that are frequently hand cultivated.

Certain soil fumigants, such as Vapam, Vorlex, and Methyl Bromide, may be used economically for the control of weeds in planting beds. These materials kill all plants, so they are used before the beds are planted. They may be used only when the soil temperature is near 60°F, and there is a waiting period of 10 to 14 days, until the fumes have dissipated, before the crops can be planted. These materials also give good control of many soil-borne insects and diseases. Except in the case of high value field crops, these materials are too costly to be used on a large scale for plants in the field.

Granular or soluble forms of selective herbicides may be used for beds or field crops. They are applied after the crops have been planted. Care must be taken that none of the material is accidentally applied to the leaves of the crop plants, otherwise severe injury may result. Most herbicides give the best control when applied to clean cultivated areas. Applied in this manner they kill germinating weed seeds before they break through the soil surface. If the materials are incorporated into the soil immedi-

ately after being applied to the soil surface, more thorough and longer lasting results may be expected. The appropriate time of application varies with the kinds of weeds to be controlled, the growth stage of the weeds, the particular herbicide being used, and the growth stage of the crop plant. Annual weeds, such as crabgrass, knotweed,and pigweed, are controlled by spring application; while perennial weeds, such as wild carrot, quackgrass, and Canada thistle are more effectively controlled by fall applications. Nursery stock is least likely to be injured by selective herbicides if the crop plant is not actively growing at the time of application.

The selection of an appropriate herbicide and the careful application at the prescribed rate are essential if good control of weeds without crop damage is to be obtained. Reference 50. 1971 Weed Control for Ornamental Crops,gives several useful tables. One lists the major nursery crops and the tolerance of each to 8 herbicides. Another table lists the major weeds and indicates which of 8 herbicides gives effective control. A third table gives rates of application and additional recommendations. Current recommendations available through the local cooperative extension service should be obtained before selective herbicides are applied to nursery stock.

Insect Control

Insect attacks can render nursery stock unmarketable or can reduce the quality of the plants. Some kinds of insects attack the leaves, flowers, and stems; others attack the roots; and some bore within the trunks and branches. Some pests, such as spider mites and slugs, are not true insects, but the controls for them are very similar.

As was pointed out in the section on Weed Control, insect problems can be reduced by controlling weeds in the nursery. Cleanliness in the propagation areas can also aid in controlling pests.

It takes careful and continuous observation to determine the symptoms of the plant injury that are typical of a certain insect pest, particularly if the pest is a very active one. Grasshoppers, Japanese beetles, and leaf-hoppers, for example, feed on plants and quickly move on. Grubs or nemas feeding on the roots of a plant may cause no readily seen injury symptom except a decline in the growth rate of the plant.

Some insect pests commonly found in nurseries in the Northeastern States are: aphid, spider mite, Japanese beetle, Codling moth, thrips, cabbage and sulfur butterfly caterpillars, wireworm, leafhopper, several kinds of scales, and slug. Many of these are illustrated and described in Reference 23, Insects Identification Manual.

Insect pests in nurseries are usually controlled by applications of pesticides in dust or spray form. In order to gain control of certain kinds, spider mites, for example, the pesticide may have to be applied 3 or 4 times at 3 day intervals. Other pests may be effectively controlled with one application. Tractor-drawn dusters and sprayers are frequently used for applying the materials. Large nurseries sometimes hire specialists to apply pest control materials from airplanes or helicopters.

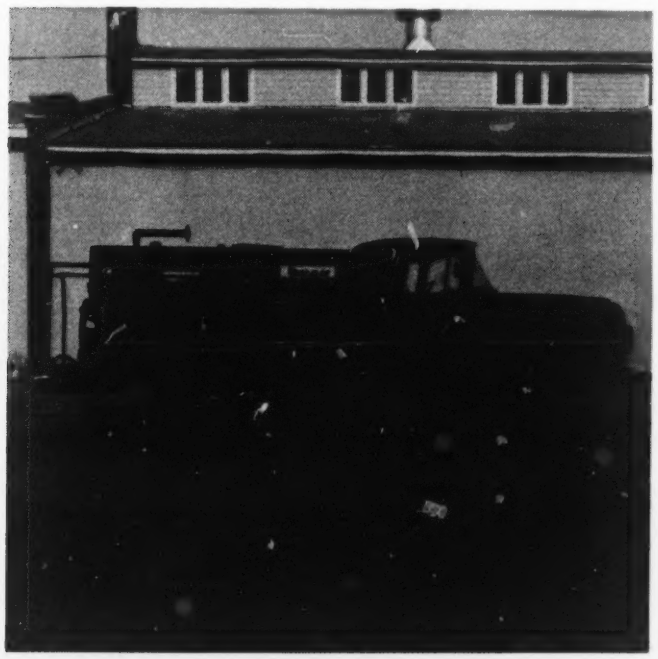


Figure 84. A nursery sprayer mounted on a truck.

Not only must the pesticide be placed in contact with the pest, which is frequently on the lower leaf surface, but the pesticide must be the right kind to kill the pest. After the pest has been identified, one can find the right pesticide to use by checking in a publication such as Reference 37, 1971 Recommended Insecticides and Miticides. With experience, one gets to know which pests to watch for each week during the growing season. Because new pesticides are being developed at a rapid rate, it is a good idea to keep posted with the latest recommendations from the State Agricultural Experiment Stations.

All pesticides should be regarded as hazardous to humans, and safety recommendations for their use should be carefully followed. An excellent publication on this subject is Reference 39, Spec. Circ. 138 Safety in Applying Pesticides Commercially. Figure 85 illustrates the

Warning on the back cover of Reference 37, 1971 Recommended Insecticides and Miticides.

Warning

Use pesticides only when necessary.

Use pesticides only at the recommended dosages and timing to keep residues on crops and animals within the limits set by law.

Avoid spray or dust drift to other crops and bee yards. Cover food and water containers in livestock areas.

Read the label and follow the safety precautions stated. Maintain a pesticide use record and inventory.

Wear protective masks and clothing if so directed on the label.

Avoid inhaling pesticides. Never eat or smoke while spraying or dusting.

Avoid spilling spray materials on skin or clothing. If spilled, wash off immediately with soap and water.

Wash hands and face and change to clean clothing after spraying or dusting. Wash spray clothing after each day's use.

Store pesticides in original containers and out of reach of children, pets, or livestock and away from food or feed. Keep pesticides in a locked storeroom or cabinet marked "Pesticides—Keep Out".

Dispose of empty containers so that they are no hazard to man, especially children, and animals.

Do not contaminate streams, ponds, and water sources or otherwise endanger wildlife.

If poisoning symptoms develop from pesticides, medicines, or any other poison source, show your physician a label of the material involved. He can phone one of the Poison Control Centers for complete information as to treatment.

before using any pesticides read the precautions

Figure 85. Precautions in the use of insecticides and miticides.

Disease Control

Disease can kill or damage nursery plants to the point where high crop losses become a serious problem. Disease and insect-carrying plants also will not pass state and federal quarantine inspections for shipment out of certain areas. For further information about quarantine regulations, read about it in Chapter 8, Marketing, pp. 185 to 187.

Preventive control of plant diseases is more economical than eradication once trouble starts. Careful inspection of all stock brought into the nursery, with rejection of infected stock, is an important preventive measure. Control of weeds and general cleanliness are important. All propagation growing mediums, for small plants in pots and for beds, should be steamed or fumigated for the control of soil-borne diseases and nemas (nematodes). These treatments also control insects and weeds.

Identification of plant diseases is often difficult. Usually the easiest approach is to look up the plant involved in a book such as Reference 13, Diseases and Pests of Ornamental Plants. Under each plant, descriptions of the diseases which commonly affect it are given. The three general groups of diseases that are troublesome on plants are bacteria, fungi, and viruses. Bacteria often cause stem or root rots and leaf or stem spots on nursery plants. Fungus diseases frequently attack the leaves of plants, as in the case of powdery mildew and black spot. Other fungi sometimes invade the roots and stems of plants. Both bacteria and fungi may be spread from infected propagation stock, or contaminated growing mediums, but some kinds are carried through the air from infected weed or wild plants in the hedgerows and other undisturbed areas of a nursery. Viruses live within the tissues of plants. Viruses may stunt plants severely, but rarely kill them. They are often brought into the nursery on propagation material. Healthy plants can become infected by the feeding of sucking insects (such as leafhoppers) that previously fed on virus infected plants.

Nemas are microscopic eel-like creatures that invade roots, stems, or leaves of plants and greatly reduce the plant vigor. Their control in the field is particularly difficult, and may require frequent applications of a nematicide drench.

Control measures for diseases of nursery plants change from year to year, so it is a good idea to keep posted with such publications as Reference 18, 1971 Fungicides and Nematocides. Safety precautions tions in the use of these chemical compounds should be carefully followed.

Winter Protection

Most nurseries plant windbreaks on the windward sides of fields in order to reduce the wind velocity during winter months. Plantings of narrowleaf and broadleaf evergreens are usually provided with evergreen windbreaks to reduce greatly the wind speed and to shade the plants from bright winter sunlight. Evergreens are especially susceptible to drying injury during winter months, when roots may be unable to take up enough water quantity to replace that lost through the leaves on sunny days.

Some nurseries have found that double row plantings of field corn, running north and south, between every 6th row of evergreens give good protection if left standing over winter.

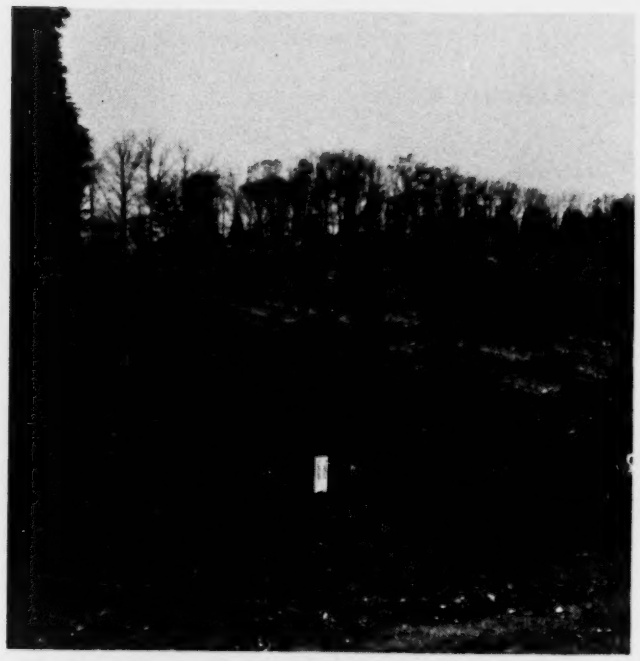


Figure 86. A windbreak of evergreens.

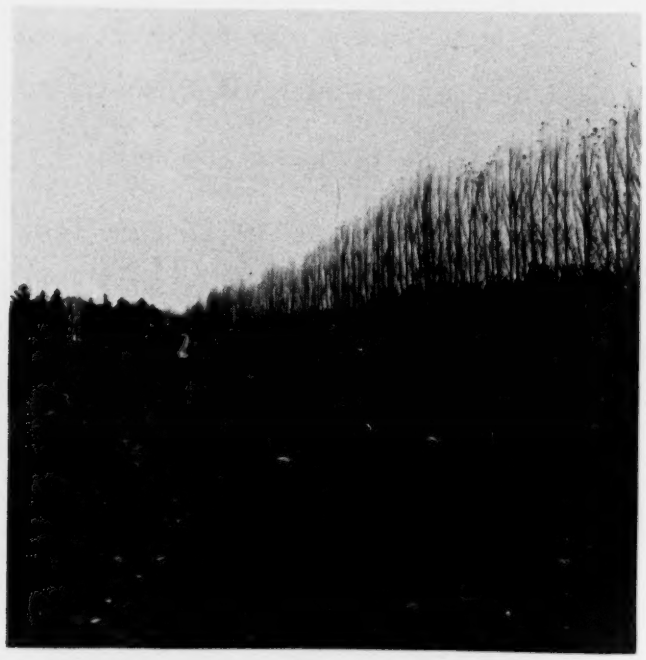


Figure 87. A windbreak of deciduous trees.

Deer, and rabbits, and other rodents, can cause considerable damage to fruit trees, dogwood, and several species of shrubs by eating the bark during winter months. Traps and poison baits and repellants are effective,

but frequent inspection during the winter is needed in order to determine when and where to use them. Poisons and traps must be used in such a way as to avoid accidental poisoning or injury to children, pets, and desirable wildlife.

Nurserymen have recently found that certain deciduous shrubs, and both needleleaved and broadleaved evergreens that have been dug B&B in the fall, may be successfully wintered in polyethylene-covered structures in the same manner as container stock (see pages 162 through 164). This technique has the additional advantage of reducing the work load in the spring, when the nursery is operating at peak capacity. The digging of B&B stock in the spring may be seriously delayed by wet weather--such delays in fall digging are less serious in affecting adjustments of the work schedules.

Culture of Specific Crop Groups

Although all nursery plants require regular attention so far as moisture, nutrition, pest control, and weed control are concerned, each group has slightly different cultural requirements from the others in such matters as wind tolerance, appropriate pruning, transplanting requirements, soil pH, soil type, and length of time to reach marketable size.

Deciduous Shade Trees

Deciduous shade trees are less frequently started from seeds than by bud grafting. Patented or other selected types are propagated by bud grafting onto seedling root stocks. A few, such as ginkgo, willow, and hybrid poplars, are commonly propagated by cuttings.

Small trees are usually lined out in the field as 1 or 2 year-old plants, (seedlings, cuttings, or grafts) at an 18 inch spacing. Bud grafts and certain cultivars with stems that tend to bend are tied to individual stakes to prevent wind breakage and to assure straight trunks. As the young trees grow, they are pruned to maintain one main stem, and as they increase in age, they are usually pruned to give lateral branches at about 18 inch spacing. Long laterals are headed back to improve the symmetry of growth. About the 4th year every other tree is removed to increase the spacing to 36 inches for the remaining trees. The removed trees are sold at that size or are replanted for growing on at a 36 inch spacing. Trees are root pruned every 3 to 4 years as described in the section on pruning. If the

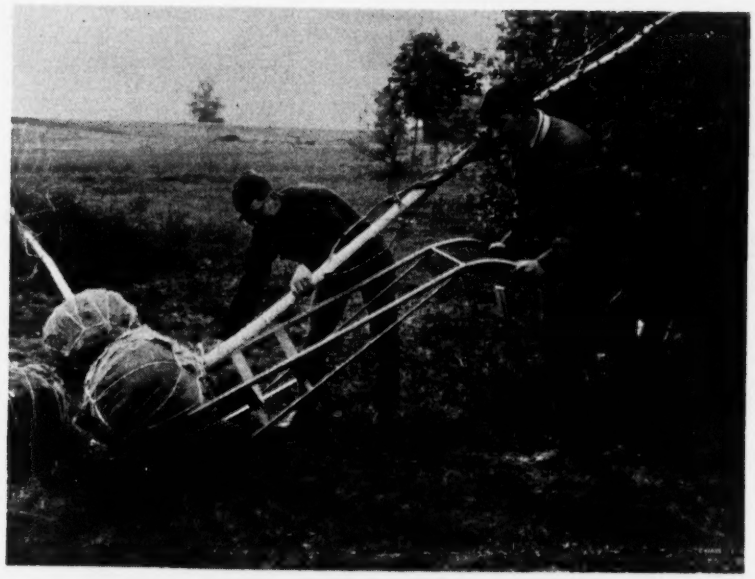


Figure 88. Deciduous trees over 2 inch caliber are dug B&B. (Courtesy E. Sealover, Cumberland Valley Sr. H.S., Mechanicsburg, Penna.)

trees are to be used as street shade trees, several lower branches are removed from each tree each year so that at selling time the lowest branches are about 7 feet from the ground line. After the first year, the leader should add about 12 inches or more of new growth each year. Small size deciduous shade trees, (2 inch caliber or less), are usually dug bare root; larger sizes are dug B&B. Deciduous trees, with a few exceptions, are dug, bare root as well as B&B, only in the dormant state in early spring or the fall after the leaves have changed color. Bare-root stock is often held in common or cold storage over winter so that early spring deliveries are possible. Some deciduous trees, such as Norway Maple, may be dug B&B during the summer after shoot growth has stopped. These require special attention to watering, and the foliage is usually sprayed with a special water-emulsified plastic to reduce transpiration.

Deciduous Flowering Trees

The culture of deciduous flowering trees (flowering cherries, crabapples, hawthorns, etc.) is very similar to that of deciduous shade trees. They are also lined out as 1 to 2 year old seedlings, rooted cuttings, or grafts. Most kinds are reproduced by budding. They are usually grown to marketable sizes at a spacing of 18 inches in the row. They may be pruned to a single trunk, or several leaders may be allowed to develop. Root pruning is usually done in the fall of the 3rd and 5th years. Branches within 3 to 4 feet of the ground are removed early in the 3rd or 4th growing season. Deciduous flowering trees are ready to market in 6 years or sooner. They may be dug bare root or B&B. Certain kinds, dogwoods and magnolias for example, can be moved successfully only with a soil ball.

Deciduous Trees

One to 2-year old rooted cuttings, seedlings, or grafts of deciduous shrubs are lined out at 12 to 24-inch spacings. The tops are usually pruned to increase branching close to the ground. The roots are pruned in the 2nd or 3rd spring. Medium to small growing cultivars are usually ready to be dug after 3 years in the field: large growing cultivars are ready after 4 years. Most deciduous shrubs are dug bare root, although deciduous azaleas, rhododendrons, and euonymus must be dug B&B.

Narrowleaved Evergreens

Narrowleaved evergreen plants are usually lined out at 2 to 3-foot spacing as 1- or 2-year old seedlings or grafts. Many, such as juniper, taxus, arborvitae, and chamaecyparis are started as rooted cuttings.

Upright growing narrowleaved evergreens may be pruned to maintain one leader, and laterals are often sheared to give dense, symmetrical growth. They are root pruned in the 3rd and 5th years, and are dug B&B after 6 years in the field.

Spreading narrowleaved evergreens are handled in the same manner as upright narrowleaved evergreens, except that they are not pruned to one leader, but laterals are pruned to encourage a natural looking form. They are root pruned in the 3rd year, and are dug B&B after 5 years in the field.

Narrowleaved evergreens are grown in an area protected from strong winter winds. A well-drained soil that contains sufficient clay to hold a soil ball is needed for production of these plants, which are dug B&B.

Broadleaved Evergreens

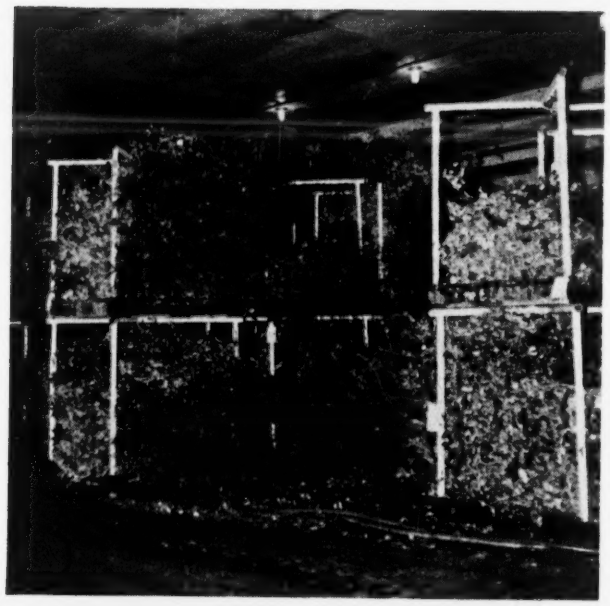
These shrubs are grown in the same manner as narrowleaved evergreen shrubs, except that the azaleas and rhododendrons require an acid soil (pH 5.0 to 6.0). These plants are also particularly susceptible to winter injury and must be grown with good windbreak protection. They are pruned to encourage dense growth. This pruning can only be done to young shoots of rhododendrons in a particular stage of shoot growth. An extra application of phosphorus fertilizer in July has been found to increase the number of flower buds formed in rhododendrons. Broadleaved evergreen plants have shallow and dense root systems; root pruning is not needed, but mulching is essential. They are usually marketed after 5 years in the field. They are dug B&B.

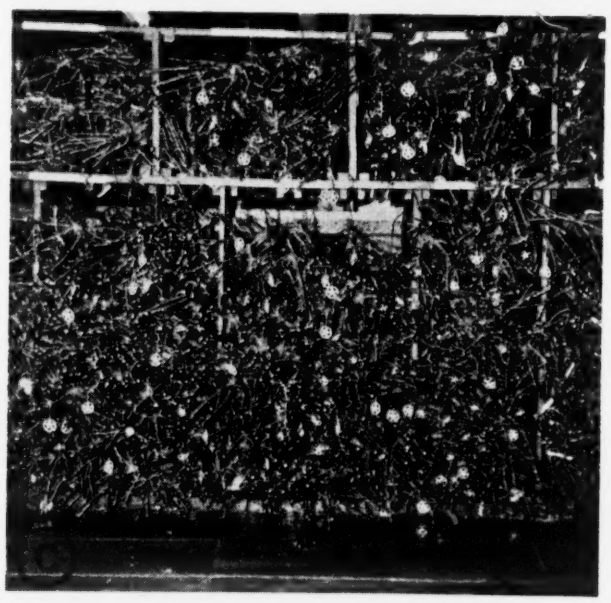
Roses

Garden roses are started by planting rooted cuttings or seedlings of special strains of Rosa multiflora at 8 to 12 inch spacing in rows in the field. These plants are used as understock for rose cultivars which are budded into them during July of the second year. This understock is used because it is more vigorous and hardy than most cultivars.

Figure 89. Field planting of roses; note contour planting and alternate cover crop. (Courtesy, Conard-Pyle Co., West Grove, Penna.)

The details of the budding operation are given in pages 453 to 454, and 461 to 466 in Reference 35, Plant Propagation Principles and Practices. In spring after the budding operation, the R. multiflora top of the plant is removed, after which the bud of the desired cultivar grows rapidly. At this time, strong winds may cause considerable damage by breaking the new shoots at the point of budding, which has not yet strongly "knitted." Each new shoot is pruned when 8 to 12 inches long in order to encourage additional





new shoot growth from the bud. Careful attention to nutrition and pest control is critical in the production of good quality garden rose plants. They are dug bare root at the end of the third year after the understock was planted, which is also the end of the second season of growth after the plants were budded. In Texas and Arizona, where the growing season is much longer than in Northeastern United States, the plants are dug at the end of the second season, or even earlier. Special machines with flails of rubber are sometimes used for defoliating the plants before they are dug in the field. Excessive foliage in storage favors the development of harmful fungus diseases. They are tied in bundles of 10 in the field and are moved quickly to a 33° to 35°F. cold storage. During winter months they are removed from the cold storage in small lots for pruning, grading, and labeling and are returned to the cold storage within a few hours of removal time. Starting in February or March, they are removed from the cold storage as orders are filled

Figure 90. Rose storage and grading. A. Roses in storage directly from the field. B. Roses being pruned and graded. C. Graded and tagged roses ready for filling orders.

and shipped. Many garden roses are patented cultivars, which means that a royalty on each plant sold must be paid to the owner of that cultivar. Each plant patent is in effect for a period of 17 years.

Vines and Groundcovers

These plants are now most commonly grown and sold as container stock, rather than as field stock. If grown in the field, evergreen and deciduous vines and groundcovers are lined out as 1 or 2 year old rooted cuttings (or grafts in a few cases--such as wisteria) at 12 inch spacing. About 3 growing seasons are required for these plants to reach marketable size. The deciduous ones are usually dug bare-root; the evergreen kinds, B&B.

Fruit trees are grown and handled in the same manner as flowering trees, except that they are shaped to give 3 to 5 main branches, and they are usually marketed at 3 to 4 years of age. Apples are budded or grafted; while peaches, plum, cherries, and apricots are budded. The use of dwarfing understock to produce plants of suitable mature size for home gardens as well as commercial plantings is becoming common. They are dug bare-root.

Small fruits, such as grapes, currants, and goosberries are usually grown from rooted cuttings that are lined out at a 12 inch spacing. Black raspberries are propagated by tip layering, while red raspberries are propagated from root suckers. They are dug bare root at the end of 1 or 2 years in the field.

Seedling trees and shrubs are sold at 2 to 3 years, (in a row spacing of 6 to 8 inches. They may be dug bare root by hand with a special spade designed for this purpose. More commonly, they are dug with a tractor-mounted blade. A few kinds that cannot be transplanted successfully bare root are grown and sold in small pots.

Bulbs, corms, and tubers are grown from 1 to 3 years from offsets or divisions that have been planted at 6 or 8 nch spacing in rows in the field. These are usually grown by specialist nurseries.

Herbaceous perennials are also usually grown by nursery specialists who plant small plants started from seeds, cuttings, or offsets, and grow them from 1 to 3 years to obtain marketable size. Smaller size plants, produced in 4 to 8 months, are being marketed in increasing numbers. Nearly all of them are dug and sold as bare-root plants. Most are sold

prepackaged in containers with a moist medium to increase their marketing life.

Digging Plants B&B and Bare-Root

Evergreens may be dug by tractor-powered diggers if large quantities are involved. Digging is more often done by two men working with spades, opposite each other on the same plant, if relatively smaller quantities are needed. The digging operation consists of making a trench around the plant and forming a good sized soil ball. In digging the trench the back of the blade of the spade should be kept toward the plant. The removed soil is pulled away from the plant. When the trench is deep enough to cut the ends of the roots of the plant, the two men insert the blade of their spades under the ball and lift it carefully from the hole. The ball is then placed on a burlap square. If the soil is loose and tends to crumble, it is advisable to raise one side of the ball while the plant is still in the hole and slide the burlap under it. The other

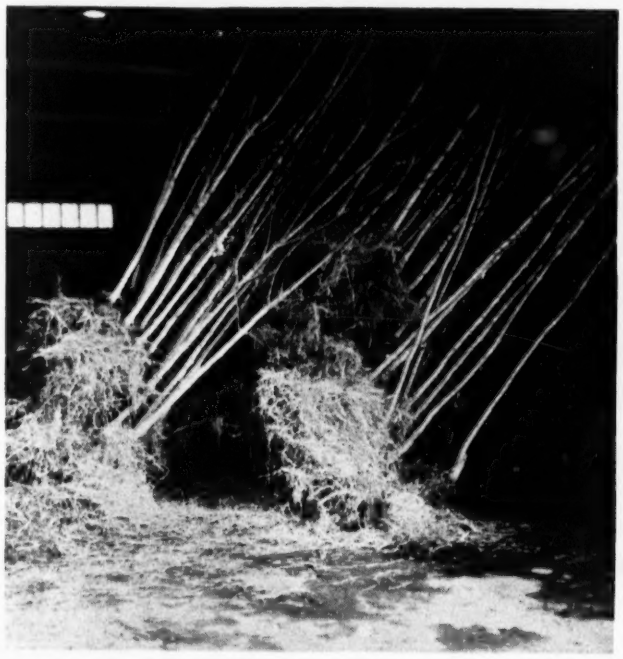


Figure 91. Bare-root trees in winter storage; roots are covered with moist shingletow.

Figure 92. Machine for digging B & B stock.

side is then lifted and the burlap is pulled through so that the entire ball will be on the burlap. Surplus soil should be removed from the ball,

and the burlap should be fastened tightly. The burlap is usually pinned tightly with nails or wire staples. The plant is then ready to be lifted from the hole. The B&B plants should be moved by holding the balls and not the tops, otherwise the soil around the roots will be loosened, roots will be broken, and the survival rate will be low.

Certain deciduous plants, flowering dogwoods and magnolias, for example, are also dug B&B because they will not tolerate being dug and handled as bare-root plants. They can be moved only in the dormant condition.

Deciduous trees and shrubs are dug in the fall after the leaves have changed color or fallen. If they are dug before reaching this dormant stage, they may grow very poorly when replanted the same fall or the following spring.

A tractor-drawn digging blade is used for digging deciduous shrubs bare-root (that is, without soil). Potato diggers are sometimes used for digging rose bushes and small deciduous shrubs. The plants are sometimes trimmed, graded, and bunched in the field. Trimming is done by removing dead, broken, and crossed branches and roots. More often, the plants are quickly moved to storage to prevent drying; and the trimming, grading, and bunching is done during the winter months when little outdoor work can be done.

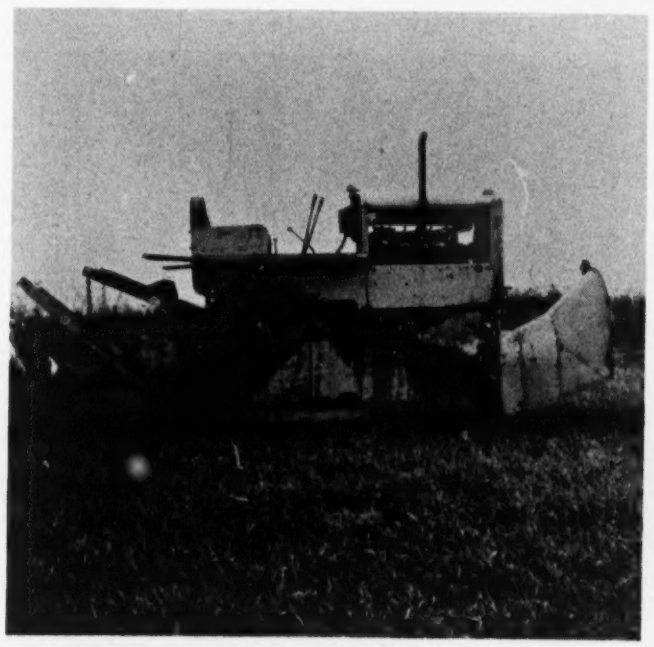


Figure 93. A crawler tractor equipped for digging deciduous shrubs. Note the metal guards to prevent injury to plant stems.

Figure 94. A root pruning blade equipped with a lifter so it can be used for digging deciduous stock.

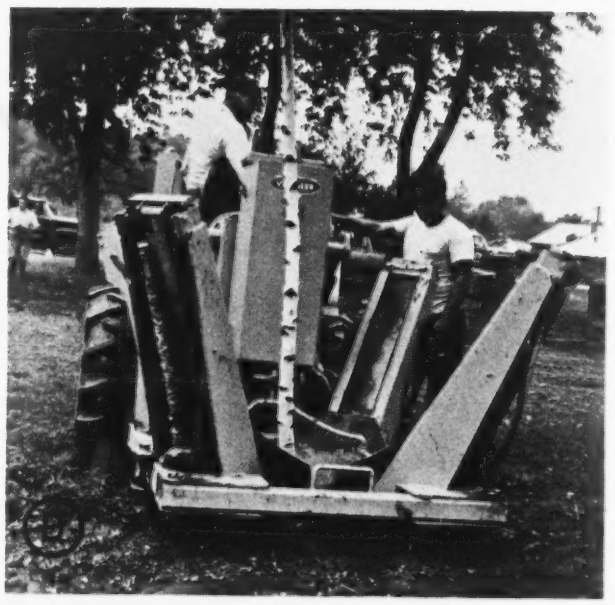


Figure 95. Steps in digging a Paper Birch with an hydraulic powered tree digger mounted on an articulated tractor. See the facing page for explanation.

The following is an explanation of Figure 95 on the facing page.

A. Digger in position, tree centered, gate open to pass around trunk of tree.

B. Gate closed and frame lowered to rest on the soil surface.

C. Blade at right rear lowered several inches; each blade inserted a few inches at a time in succession.

D. Tree lifted slightly after all blades inserted full depth.

E. Entire digger frame lifted together with tree and soil ball.

F. Tree and digger in position to be moved by tractor; tree will be placed on ground, digger removed, tip of soil cut off to give flat bottom to soil ball, then burlapped and tied with twine.

Holding Plants for Short Periods

Nursery stock that has been dug is extremely susceptible to injury if the roots become dry even once! For this reason, special techniques must be used to keep the roots moist.

Deciduous plants that have been dug bare root (in the dormant condition) and must be held for several hours, or even days, are "heeled-in" to protect the roots. "Heeling-in" is done by digging a trench in the soil about 12 to 18 inches deep. The plants are then placed in the trench as close together as possible, with the tops at about a 45 degree angle to the south (to reduce drying of the tops and to prevent sunburned trunks of trees). The soil from the trench is then filled in around the roots and lower parts of the plants. The soil must be kept moist.

Balled and burlapped nursery stock may be temporarily held also by heeling in. In this case the plants are usually placed upright in the trench, and shade is provided to prevent rapid water loss from the leaves. B&B stock is often held in shallow frames with moist sawdust, peat, wood shavings, or shingletow to prevent drying. Some nurserymen use lath-covered loading platforms with sprinkler systems in order to keep B&B stock in good condition prior to loading on to trucks.

Container-grown stock is more easily held for short periods than bare-root or B&B material because the root system has not been disturbed. These are usually simply placed on a clean, level surface and kept watered. In

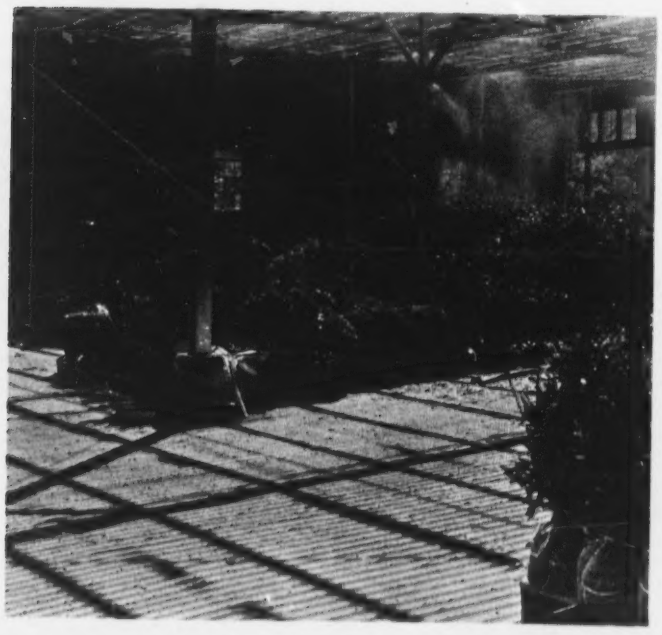


Figure 96. B&B stock in a holding area with lath shade and sprinkling system.

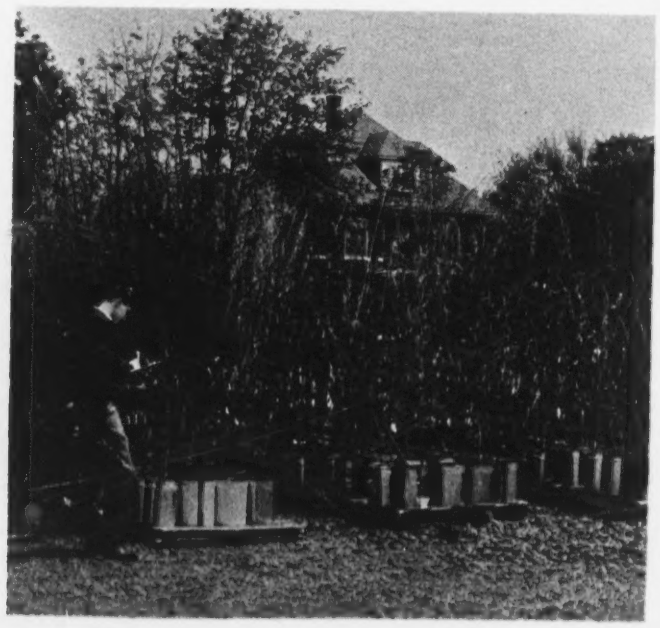


Figure 97. Container stock in a holding area.

large nursery operations, where fork lifts and pallets are used for moving stock, these plants may be held on pallets for several days if necessary.

Grading

Most nurseries throughout the U.S. have adopted, and many exceed, the grades published in Reference 48, U.S.A. Standard for Nursery Stock, prepared by the American Association of Nurserymen. Conformity to these grades assures that nursery stock of certain grade specifications will be uniform regardless of where it was grown. Use of these grades helps to eliminate misunderstandings between the producer and the purchaser, and permits relatively easy comparison of prices.

Reference 48 gives grade standards for the following groups of nursery plants:

1. Deciduous shade and flowering trees
2. Deciduous shrubs
3. Coniferous evergreens
4. Broadleaved evergreens
5. Roses
6. Vines
7. Fruit trees
8. Small fruits
9. Lining out stock
10. Seedling trees and shrubs
11. Bulbs, corms and tubers

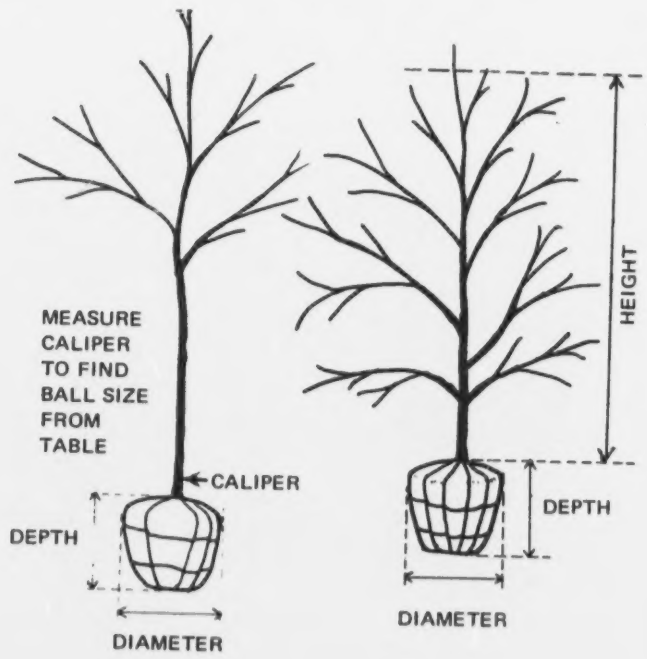


Figure 98. Measurements for deciduous trees. (Courtesy Amer. Assn. of Nurserymen, Washington, D.C.)

The grades are based upon measurements of specific parts of the plant. In the case of shade trees, the measurements used are: trunk caliper, height, and root spread or soil ball diameter. For pyramidal coniferous evergreens the measurements used include: height, spread, and soil ball diameter. For specific details for grades of the 11 groups, you should read Reference 48. Some examples of measurements are given Figures 98, through 104.

PYRACANTHA coccinea wyatti - 8'
Wyatti Pyracantha

A very hardy variety producing clusters of large orange-red berries in early fall. Compact grower.

1 gallon cans	3.00
5 gallon cans	9.00

PYRACANTHA wyatti espalier Trained Pyracantha

A hardy Pyracantha trained upright for planting along walls, fences, etc.

5 gallon cans	16.00

PYRUS calleryana bradford - 40'
Callery or Bradford Pear

Masses of white flowers. Glossy green foliage turning bright crimson in fall. Tiny fruits loved by birds.

5 gallon cans - 8 to 9 ft. high	15.00

QUERCUS borealis "rubra" - 80' **Red Oak**

Rapid grower. Stately. Attractive fall foliage.

8 to 10 ft. B&B	25.00
1½ to 2 in. caliper B&B	45.00
3½ to 4 in. caliper B&B	140.00
4 to 4½ in. caliper B&B	160.00
4½ to 5 in. caliper B&B	210.00
5 to 6 in. caliper B&B	250.00
6 to 7 in. caliper B&B	300.00

QUERCUS coccinea - 80' **Scarlet Oak**

Brilliant fall color. Rather fast grower. Strong tree.

6 to 8 ft.	8.00
8 to 10 ft. B&B	25.00
1 to 1½ in. caliper B&B	35.00
1½ to 2 in. caliper B&B	45.00
2 to 2½ in. caliper B&B	75.00

QUERCUS palustris - 80' **Pin Oak**

Fastest grower of Oaks. Apparently free from disease and insects. A truly fine shade tree.

6 to 8 ft.	7.50
1 to 1¼ in. caliper	12.00
1¼ to 1½ in. caliper	16.00
1½ to 1¾ in. caliper	20.00
1¾ to 2 in. caliper B&B	40.00
2 to 2½ in. caliper B&B	60.00
2½ to 3 in. caliper B&B	100.00
3 to 3½ in. caliper B&B	120.00
3½ to 4 in. caliper B&B	140.00
4 to 4½ in. caliper B&B	160.00
4½ to 5 in. caliper B&B	200.00
5 to 6 in. caliper B&B	250.00
6 to 7 in. caliper B&B	300.00
7 to 8 in. caliper B&B	350.00
8 to 9 in. caliper B&B	400.00
9 to 10 in. caliper B&B	450.00
10 to 12 in. caliper B&B	500.00

Figure 99. Grades of stock in a retail nursery catalogue.

An example of nursery grades in a nursery price list is shown in Figure 99 .

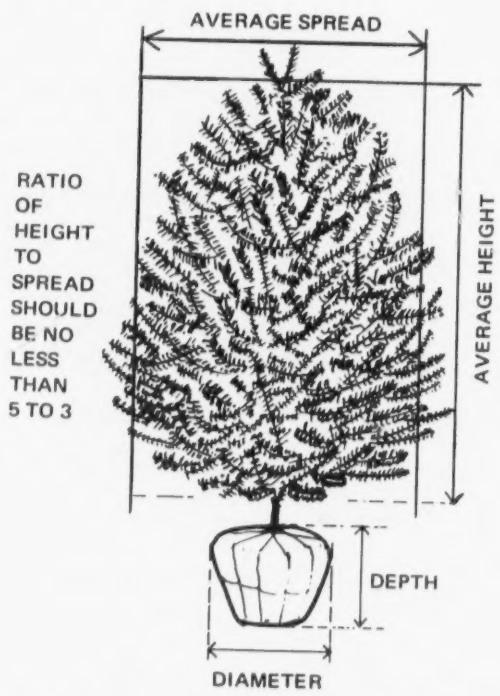


Figure 100. Measurements for coniferous evergreens (Courtesy Amer. Assn. Nurserymen, Washington, D.C.)

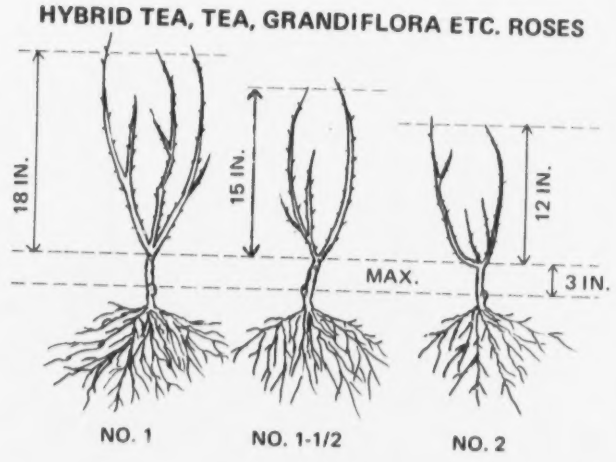


Figure 101. Measurements for roses (Courtesy Amer. Assn. Nurserymen, Washington, D.C.)

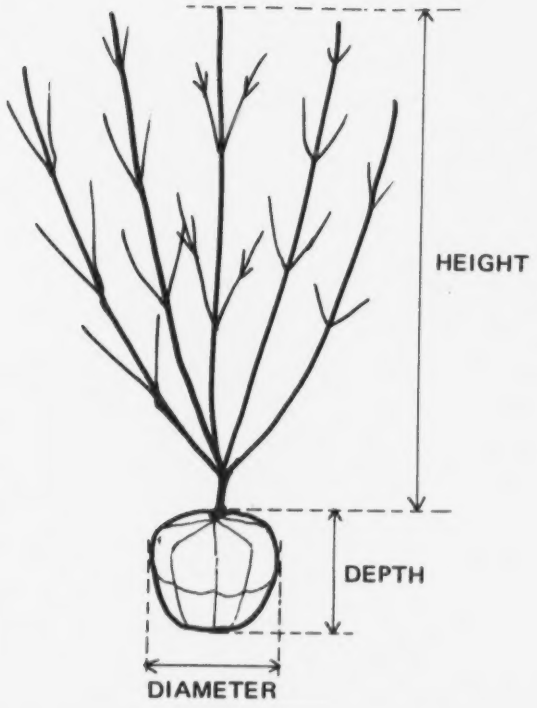


Figure 102. Measurements for B&B deciduous plants. (Courtesy Amer. Assn. Nurserymen, Washington, D.C.)

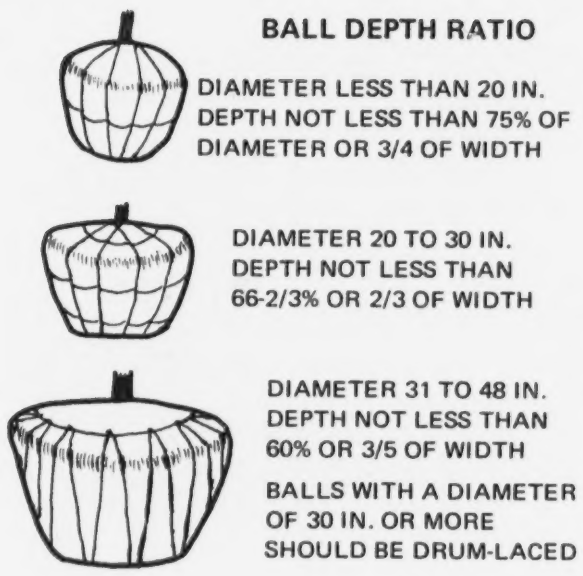

BALL DEPTH RATIO
DIAMETER LESS THAN 20 IN.
DEPTH NOT LESS THAN 75% OF
DIAMETER OR 3/4 OF WIDTH
DIAMETER 20 TO 30 IN.
DEPTH NOT LESS THAN
66-2/3% OR 2/3 OF WIDTH
DIAMETER 31 TO 48 IN.
DEPTH NOT LESS THAN
60% OR 3/5 OF WIDTH
BALLS WITH A DIAMETER
OF 30 IN. OR MORE
SHOULD BE DRUM-LACED

Figure 103. Measurement ratios for soil balls. (Courtesy Amer. Assn. Nurserymen, Washington, D.C.)

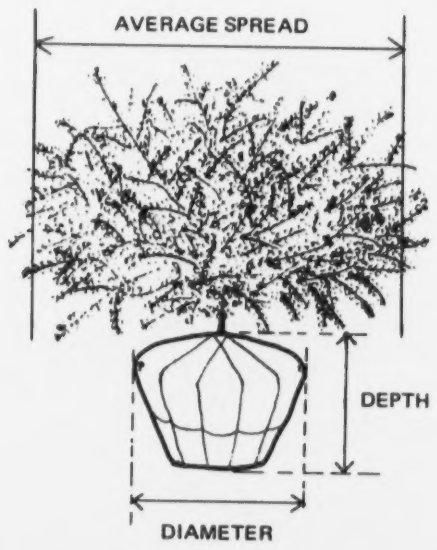


Figure 104. Measurements for B&B broadleaved evergreens. (Courtesy Amer. Assn. Nurserymen, Washington, D.C.)

Abbreviations

The nursery trade uses abbreviated terminology in describing plants. The following abbreviations are commonly found in nursery catalogs. To be able to use a nursery catalog these abbreviations must be understood: S - seedling, T or X - once transplanted; TT or XX - twice transplanted, RC - rooted cutting; and RCT - root cutting transplanted.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Reference

Insects Identification Manual, Calif. State Polytechnic College, San Luis Obispo, CA, 1966.

Safety in Applying Pesticides Commercially, Special Circular 138, Penn State Univ., Col. of Agr. Ext. Serv., University Park, PA.

USA Standard For Nursery Stock, American Association of Nurserymen, Inc., Washington, DC, 1969.

1971 Fungicides and Nematocides, Penn State University, Col. of Agr. Ext. Serv., University Park, PA.

1971 Recommended Insecticides and Miticides, Penn State University, Col. of Agr. Ext. Serv., University Park, PA.

1971 Weed Control for Ornamental Crops, Penn State Univ., Col. of Agr. Ext. Serv., University Park, PA.

Audio-Visual Aids

Among Your Souvenirs, (16 mm., color, sound, 13½ min.) Quarantine Inspec. Film Bookings, Motion Picture Service, U.S.D.A., Washington, DC, 20250.

Diseases of Horticultural Crops, Trees, Turf and Wood Roots. Slide set A-521b. Photo. Div., Office of Inf., U.S. Dept. of Agr., Washington, DC, 20250. 112 slides, $17.00.

Insects of Horticultural Crops and Shade and Forest Trees. Slide set A-52d. Photo, Div., Office of Inf., U.S. Dept. of Agr., Washington, DC, 20250. 94 slides, $13.50.

Prescription for Safety, (16 mm., color, sound, 18 min.) pesticides. Natl. Agr. Chem. Assn., 1155 15th St. N.W., Washington, DC, 20005.

The Pest Control Operator, (16 mm., color, sound, 14 min.) Velsicol Chem. Corp., 330 East Grand Ave., Chicago, IL, 60611.

Suggested Learning Activities

1. Have students take a soil sample for the school nursery and submit it to a soil analysis laboratory. When the report is received, discuss the recommendations in detail, and follow them if possible.
2. Have students learn to calibrate a fertilizer spreader.
3. In early spring, have students line out nursery stock representative of each of the 11 groups listed on page 139. This can be done in the school nursery, or make arrangements for students to do this in a

local nursery.

4. Have students learn to safely operate tractors and attachments. See Appendix B for further information. As they gain skill, give them exercises in maneuvering tractors with attachments in a mock up nursery in a large paved or grass area.
5. If a local nursery has a transplanting machine, arrange for the class to see it in operation. If possible, arrange for students to do planting with the machine.
6. Arrange for students to see a demonstration of pruning of trees, deciduous shrubs and evergreens at a local nursery. Follow this with pruning exercises using plant material in the school nursery.
7. So students may understand how root systems grow, have students working in pairs carefully unearth a 2 to 3 year old woody plant, keeping as much of the root system as possible. If each pair works with a different kind of plant, interesting comparisons of root systems can be made.
8. Arrange for students to see a root pruning operation in a local nursery. Have students root prune stock in the school nursery.
9. Have students determine the kinds of weeds to be controlled in the school nursery, and help them select the appropriate herbicide, taking crop tolerance into consideration. They should determine the rate and method of application, and apply the material. In spring this can be done for the control of annual weeds; in fall, for perennial weeds.
10. In May or September have students collect examples of pests and diseases of ornamental plants. Each should be correctly identified and the control measures discussed.
11. Provide students with experience in dusting and spraying nursery stock for the control of insects and diseases. Reference 39. Safety in Applying Pesticides Commercially should be thoroughly studied by each student and discussed by the class before this activity.
12. In late October have students apply a rodent repellant to the trunks and branches of susceptible plants. Deliberately omit application to several plants for demonstration purposes. The effectiveness of the treatment should be determined in April.

13. In October or April have students working in pairs dig marketable size crops from the school nursery. They should become skilled in digging both bare-root and B&B stock. These plants should be properly labeled for identity and grade. This stock could be used for landscaping the school grounds or public buildings, sold wholesale to local nurserymen, or sold retail to students and faculty. If facilities are available, fall dug stock could be held over winter if desirable.
14. Arrange for the class to see hydraulically operated tree and shrub diggers in operation at a local nursery.

Test

1. Why must a nursery crop rotation be carefully planned?
2. Why is a planting block put into a green manure crop for a year or two before it is replanted with a nursery stock?
3. How does one determine whether a soil is in the right condition to be worked?
4. What kind of soil is best for growing bare-root stock? B&B stock?
5. Give 2 reasons why nurserymen often plow in the fall rather than spring.
6. How frequently should nursery soils be sampled and tested?
7. Why are certain kinds of young nursery stock grown in beds?
8. What is a "liner"? When are they planted?
9. How can one determine when field stock needs to be watered?
10. Why is young nursery stock watered more frequently than older stock?
11. Why must plants be watered heavily immediately after transplanting?
12. What is the main purpose of a mulch?
13. How much new growth should a tree make each year?
14. Why do some nurserymen think that fall applications of fertilizer are more beneficial than spring applications?
15. Why are trees grown with a single leader?
16. Why are long laterals in trees and shrubs pruned back to the length of the other laterals?

17. Give 2 reasons why certain kinds of young trees are tied to stakes for support.
18. Why is nursery stock root pruned?
19. How frequently should the soil between rows of plants be cultivated? Why?
20. Under what circumstances are herbicides used?
21. How does one decide which particular herbicide to use?
22. Why is it important to identify both the crop and the pest before applying a pesticide?
23. What is the difference between an insecticide and a fungicide?
24. Describe 2 kinds of winter injury and give the control measures for each.
25. Why are garden roses budded?
26. What kinds of plants are dug bare root? Balled and burlapped? Why?
27. Give the special soil requirements of rhododendrons and azaleas.
28. Describe "heeling in."
29. Give the three measurements that are used to describe a grade of a shade tree.
30. Give the appropriate word(s) for each of the following nursery abreviations:

    S

    TT (or XX)

    RC

    RCT

The following table, Table 8a. Recommended School Nursery Planting and Rotation Plan for Field Grown Stock, illustrates in simplified form how a rotation may be planned. This plan is for only 55 kinds of nursery plants in small quantities. A commercial nursery would probably grow over 200 kinds in large quantities, and herbaceous perennials (2 year rotation) might be grown in addition to woody plants.

The left hand column in Table 8a lists seven types of plants. Table 8b lists plants recommended for this rotation plan, which was worked out for plant hardiness zone 6. Additional examples of plants within each of these types may be seen in Appendix A, Recommended Trees and Shrubs for School Arboretums.

TYPE OF PLANT	SPACING BETWEEN ROWS	SPACING IN ROWS	BLOCKS							LENGTH OF ROTATION
STANDARD DECIDUOUS TREES (A) (7 SPECIES)	5'	18"	A-1 PLANT 1971 THIN 1974 HARVEST '76 COVER CR.'77 REPLANT '78	A-2 PLANT 1972 THIN 1975 HARVEST '77 COVER CR.'78 REPLANT '79	A-3 PLANT 1973 REPLANT '80	A-4 PLANT 1974 REPLANT '81	A-5 PLANT 1975 REPLANT '82	A-6 PLANT 1976 REPLANT '83	A-7 PLANT 1977 REPLANT '84	7 YEARS
SMALL DECIDUOUS TREES (B) (6 SPECIES)	4'	18"	B-1 PLANT '71 THIN '74 HARVEST '75 COVER CR.'76 REPLANT '77	B-2 PLANT '72 THIN '75 HARVEST '76 COVER CR.'77 REPLANT '78	B-3 PLANT '73 REPLANT '79	B-4 PLANT '74 REPLANT '80	B-5 PLANT '75 REPLANT '81	B-6 PLANT '76 REPLANT '82		6
EVERGREEN TREES (C) (8 SPECIES)	4'	2'	C-1 PLANT '71 HARVEST '75 COVER CR.'76 REPLANT '77	C-2 PLANT '72 REPLANT '78	C-3 PLANT '73 REPLANT '79	C-4 PLANT '74 REPLANT '80	C-5 PLANT '75 REPLANT '81	C-6 PLANT '76 REPLANT '82		6
NARROW-LEAF & BROAD-LEAF EVERGREEN SHRUBS (D) (6 SPECIES)	4'	2'	D-1 PLANT '71 HARVEST '74 COVER CR. '75 REPLANT '76	D-2 PLANT '72 HARVEST '75 COVER CR. '76 REPLANT '77	D-3 PLANT '73 HARVEST '76 COVER CR. '77 REPLANT '78	D-4 PLANT '74 HARVEST '77 COVER CR. '78 REPLANT '79	D-5 PLANT '75 HARVEST '78 COVER CR. '79 REPLANT '80			5
LARGE DECIDUOUS SHRUBS (E) (6 SPECIES)	4'	1'	E-1 PLANT '71 HARVEST '73 COVER CR. '74 REPLANT '75	E-2 PLANT '72 HARVEST '74 COVER CR. '75 REPLANT '76	E-3 PLANT '73 HARVEST '75. COVER CR. '76 REPLANT '77	E-4 PLANT '74 HARVEST '76 COVER CR. '77 REPLANT '78				4
MEDIUM DECIDUOUS SHRUBS (F) (6 SPECIES)	4'	1'	F-1 PLANT '71 HARVEST '72 COVER CR. '73 REPLANT '74	F-2 PLANT '72 HARVEST '73 COVER CR. '74 REPLANT '75	F-3 PLANT '73 HARVEST '74 COVER CR. '75 REPLANT '76					3
SMALL DECIDUOUS SHRUBS (G) (6 SPECIES)	4'	1'	G-1 PLANT '71 HARVEST '72 COVER CR. '73 REPLANT '74	G-2 PLANT '72 HARVEST '73 COVER CR. '74 REPLANT '75	G-3 PLANT '73 HARVEST '74 COVER CR. '75 REPLANT '76					3
DECIDUOUS & EVERGREEN VINES AND (H) GROUND COVERS (8 SPECIES)	4'	1'	H-1 PLANT '71 HARVEST '72 COVER CR. '73 REPLANT '74	H-2 PLANT '72 HARVEST '73 COVER CR. '74 REPLANT '75	H-3 PLANT '73 HARVEST '74 COVER CR. '75 REPLANT '76					3

260'

SCALE 0 5' 10' 15' 20'

200'

Table 8a. Recommended school nursery planting and rotation plan for field-grown stock. (Adopted from a plan by Robert O. Leiter).

Note: This is Figure 30, page 32, in Facilities for Instruction in Ornamental Horticulture.

Table 8b. Species of Woody Ornamental Plants Recommended for Field-Grown Stock in a School Nursery.

STANDARD DECIDUOUS TREES

Sugar Maple	Acer saccharum
Red Maple	Acer rubrum
Green Ash	Fraxinus lanceolata 'Marshall's Seedless'
Moraine Locust	Gleditsiz tricanthos inermis 'Shademaster'*
Sweet Gum	Liquidambar styraciflus
Red Oak	Quercus borealis
Pin Oak	Quercus palustris
Littleleaf Linden	Tilia cordata

SMALL DECIDUOUS TREES

Japanese Maple	Acer palmatum
Eastern Redbud	Cercis canadensis
Dogwood	Cornus florida
Washington Hawthorn	Crataegus phaenopyrum
Saucer Magnolia	Magnolia soulangeana
Sargent Crabapple	Malus sargenti
Kwanzan Cherry	Prunus serrulata 'Kwanzan'

EVERGREEN TREES

White Fir	Abies concolor
American Holly	Ilex opaca
Southern Magnolia	Magnolia grandiflora
Norway Spruce	Picea abies
Koster Blue Spruce	Picea pungens 'Koster'
White pine	Pinus strobus

LARGE DECIDUOUS SHRUBS

Smoke Bush	Cotinus coggyria 'Purpureus'
Shrub Althea	Hibiscus syriacus
Beauty Bush	Kolkwitzia amabilis
Amur Privet	Ligustrum amurense
Hybrid Lilac	Syringa hybrid
Siebold Viburnum	Viburnum sieboldi

MEDIUM DECIDUOUS SHRUBS

Snowflake Deutzia	Deutzia scabra candidissima
Dwarf Winged Euonymus	Euonymus alatus compactus
Forsythia	Forsythia intermedia spectabilis
Bridalwreath Spirea	Spirea prunifolia plena
Persian Lilac	Syringa persica
Fragrant Viburnum	Viburnum carlesi
Linden Viburnum	Viburnum dilitatum
Weigela	Weigela 'Bristol Ruby'

SMALL DECIDUOUS SHRUBS

Rockspray Cotoneaster	Cotoneaster horizontalis
Dwarf Flowering Almond	Prunus glandulosa
Spirea Anthony Waterer	Spirea bumalda 'Anthony Waterer'
Dwarf Cranberrybush Viburnum	Viburnum opulus nanum

Red Pine	Pinus resinosa
Canada Hemlock	Tsuga canadensis

NARROWLEAF EVERGREEN SHRUBS

Pfitzer Juniper	Juniperus chinensis pfitzeriana
Andora Juniper	Juniperus horizontalis plumosa
Mugho Pine	Pinus mugo mugus
Brown Spreading Japanese Yew	Taxus cuspidata 'Browni'
Hick's Yew	Taxus media 'Hicksi'
Ware's Arborvitae	Thuja occidentalis 'Wareana'

*patented

DECIDUOUS AND EVERGREEN VINES AND GROUND COVERS

American Bittersweet	Celastrus scandens
Clematis	Clematis hybrids
English Ivy	Hedera helix
Japanese Wisteria	Wisteria floribunda
Carpet Bugle	Ajuga reptans
Creeping Juniper	Juniperus horizontalis
Japanese Spurge	Pachysandra terminalis
Myrtle or Periwinkle	Vinca minor
Purpleleaf Wintercreeper	Euonymus fortunei coloratis

CHAPTER 7

GROWING NURSERY STOCK IN CONTAINERS

Learning Objectives

1. To recognize the kinds of containers used in growing nursery stock.
2. To understand how to mix growing mediums for container-grown nursery stock.
3. To know the best means of watering container-grown stock.
4. To be able to shape container-grown nursery stock by pruning.
5. To understand pest control problems with container-grown nursery stock.
6. To know how to prepare and handle container-grown stock for sale.

Key Questions

1. What are the best kinds of growing mediums to use in growing potted plants?
2. Why are sand and peat mixtures often used for container stock?
3. Why is it important to sterilize the growing medium before planting?
4. Why is it better to use potted liners than bed-grown liners?
5. What kinds of containers are best for growing container nursery stock?
6. Which insect and disease problems are most common in container-grown nursery stock?
7. Why is it important that containers be properly spaced in the growing area?
8. When and how is container-grown stock pruned?
9. How is fertilizer applied to the container-grown nursery plants?
10. What types of automatic watering systems are being used for container-grown nursery stock? Describe how they operate.
11. What special problems must be overcome in wintering container stock.

Key Words

Asexual or vegetative propagation - using parts of a plant (shoots, stems, leaves, roots) to produce additional plants

Conductor - a material (usually a metal) that transfers heat energy

Conifers - narrow leaved plants that produce seeds in cones; most of them are evergreens

Growing medium - a soil mix used for growing plants

Harden off - exposing plants to low or varying temperatures to acclimate them to outdoor growing conditions

Nemas - (nematodes) microscopic, thread like worms that may be parasites on plant roots

Pinching - removing the tip of a twig, shoot, or branch to promote growth of side shoots in order to have more dense growth of the plant

Soil mix - a mixture consisting of soil, sand, and peat or other combinations of inorganic and organic materials

Growing Nursery Stock in Containers

The production of nursery plants in containers is gradually replacing field culture of many kinds of nursery plants. The growing of nursery stock in containers has many advantages; greater production per unit of ground area is obtained, plants are more easily handled, the growing mediums are lighter in weight, the planting season is longer, no root pruning is necessary, cost per plant is lower, and the plants to be sold require no digging. Some kinds of nursery plants grow poorly if the roots are disturbed as happens when they are dug from the field -- the same kinds perform well when planted from a container, because of the reduced root disturbance. Most nurseries are growing at least some stock in containers. Therefore, it is important that persons entering this vocation have an understanding of the procedures involved in container growing of nursery plants.

In the nursery business there is a distinction between "container" stock and "potted" stock. Container stock is grown to marketable size in the container. Potted stock refers to seedlings, rooted cuttings, or recently grafted plants that are grown for a period of time in small pots before they are planted in containers or lined out in the field.

Selecting a Container

A container for growing nursery stock must be attractive, convenient to use, and must be available in large quantities at reasonable cost. It must be nontoxic to plants and must be durable enough to reach the customer in acceptable condition.

One, 2, 3, 5, and 12 gallon sizes are used. They may be made of steel, plastic, or wood. Wire baskets are sometimes used. Fabricated containers of heavy paper or compressed sawdust or bark are also used.

Painted metal containers with tapered sides are probably most often used. The color of a metal container is important. Light gray or light green are most often used because they do not detract attention from the plant. It is difficult to keep bright colored containers looking clean. Dark colors are avoided because they absorb heat. The plant ball can be slid out of the tapered container easily by the customer at planting time.

Figure 105. Tapered metal containers used for Andora Junipers.

Figure 106. One-peck baskets used for Hybrid Rhododendrons.

(Courtesy Conard-Pyle Co., West Grove, Penna.)

Tapered containers also have the advantage that they may be nested for easy storage before use. The main disadvantage of metal containers is that they are rapid conductors of heat and cold. Because roots tend to grow extensively between the growing medium and the inner wall of the container, the rapid temperature changes of the metal surfaces can be very injurious to the root system. In summer the containers become hot if exposed to the sun, and in winter they become very cold. On the other hand, these containers give good mechanical protection to the root ball of the plant in normal handling. The metal containers do not collapse when they are stacked one on top of another when loaded in a truck. Metal containers are also relatively inexpensive.

Plastic, pressed paper, and composition containers change temperature slowly, keeping the roots cooler in summer and warmer in winter. Plants are easily removed from them. New types with thick walls are tough enough to stand normal handling. They are more attractive than painted metal, containers, but may be more expensive. One-half peck and peck size wooden baskets are sometimes used. They are not good conductors of heat or cold, so they are better than plastic or metal containers in this regard. These baskets must be placed on a well-drained area or the bottoms will quickly rot out. These containers last only for 1 or 2 seasons. They also crush easily when they are stacked and loaded in a truck. The main advantage of baskets is that they drain well.

When selecting containers, the following desirable qualities should be considered:

1. Appearance - eye appeal to the buyer
2. Structural strength - withstand rough handling
3. Insulating value - protect the roots of the plant against heat and cold
4. Durability - useful for several years
5. Rust proof - resistant to rust
6. Easily stored-require minimum room for storage
7. Weight - relatively light
8. Stability - must have a low center of gravity

9. Low cost - available at prices growers can afford to pay
10. Shape - permitting normal root growth

You may wish to read "Plant Containers" Handbook, Reference No. 32.

Crop Succession Plans

Container-grown nursery stock is usually planted in early spring although some planting is done in early fall.

Most kinds of container-grown nursery stock are grown for a period of 2 years, although some stock reaches marketable size in 1 year, and a few slow-growing kinds may be grown for 3 or 4 years. Table 9, Container stock crop schedules, indicates by plant group, the size of plant, the size of container, and the years for production of container nursery plants.

The "rule of thumb" for proper spacing of container grown plants is that the leaf tips of adjacent plants should barely touch. This spacing results in compact growth of good quality. Spacing too closely results in spindly growth and browning of the lower foliage. Applying this spacing rule, most container nursery plants can be placed "pot tight," that is, as close together as is possible, for the first year of growth. At the beginning of the second year they are usually spaced as far apart as the diameter of the containers. Figure 107 shows that the removal of excess plants to

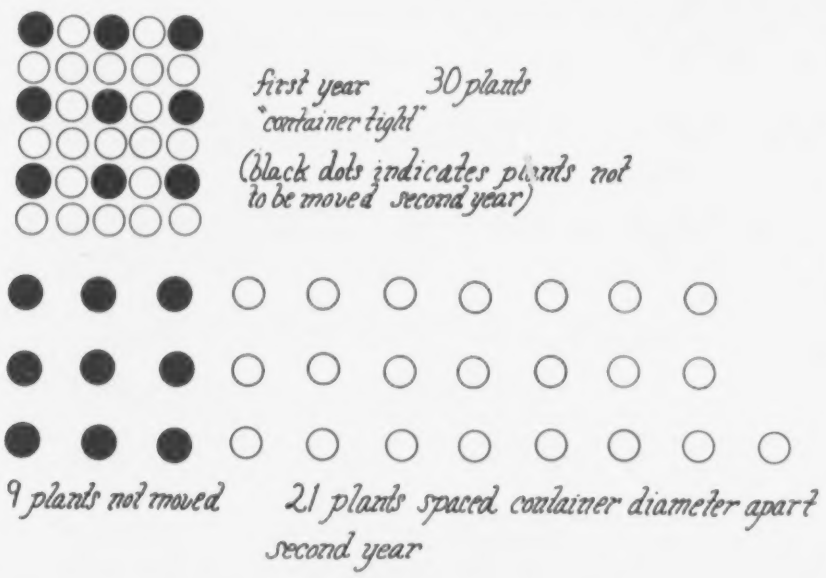

first year 30 plants
"container tight"
(black dots indicates plants not to be moved second year)
9 plants not moved
21 plants spaced container diameter apart second year

Figure 107. Container stock "pot tight" the first year is expanded to occupy 3 times the original space at the start of the second year.

provide this spacing will give enough excess plants to fill an additional space more than twice as large as the original space.

In planning the production of container stock, one must first decide which crops will be grown, the number needed each year, and the sizes required. The crop succession is simple for one year crops. Each year one crop replaces another. Crops requiring 2 years will need about 3 times as much growing space the second year as they did the first year, and this must be accounted for in planning the use of space. Crops requiring 3 or 4 years usually remain at the 2 year spacing. A 3 to 5 year crop succession plan, with the space requirements drawn to scale must be worked out in advance of planting so that costly planning errors will not be made. Such plans should include:

Total space required

A planting schedule, including kinds of plants, numbers needed, and planting dates

Number and size containers needed

Quantity of growing medium needed

Irrigation system required

Fertilizer injector required (also quantity of fertilizer)

Man-hours for planting and setting out

Man-hours for maintenance

Building space, equipment, and tools required

Winter protection structures required

All-weather surfaces for access to the plants

Table 9. Container stock crop schedules.

This schedule indicates the size of plants (in inches across the top), size of container, and production time for groups of container-grown nursery stock produced in Northeastern United States.

Plant Group*	Size Plant (top diameter)	Size Container**	Production Time, Years
Small deciduous trees	12-15" (height)	6" can	2
	15-18" (height)	6" can	2
	18-24" (height)	8" can	3
	2'-3' (height)	8" can	3
Narrowleaved evergrees shrubs	9-12"	6" can	1
	12-15"	6" can	2
	15-18"	8" can	2
	18-24"	10" can or 1 peck basket	

Plant Group*	Size Plant (top diameter)	Size Container**	Production Time, Years
Large broadleaved evergreens shrubs	10-12"	6" can	1
	12-15"	6" can	1
	15-18"	1 peck basket	2
	18-21"	1 peck basket	2
	21-24"	1 peck basket	3
	24-30"	½ bu. basket	3
	30-36"	½ bu. basket	4
	36-42"	½ bu. basket	4
Medium deciduous shrubs	12-15"	8" can	2
	15-18"	8" can	2
	18-24"	8" can	2
	24-30"	10" can	3
Medium broadleaved evergreens	12-15" (height)	8" can	2
	15-18" (height)	8" can	2
	18-24" (height)	8" can	3
	24-30" (height)	10" can	3
Small deciduous shrubs	9-12"	6" can	2
	12-15"	6" can	2
	15-18"	6" can	3
	18-24"	8" can	3
Small broadleaved evergreen shrubs	12-15"	6" can	2
	15-18"	8" can	3
	18-24"	8" can	3
Deciduous and evergreen vines	12-15" (height)	6" can	1
	15-18" (height)	6" can	1
	18-24" (height)	6" can	2
	24-36" (height)	6" can	2
Deciduous and evergreen ground-covers	12-15"	6" can	1
	15-18"	6" can	2
	18-24"	6" can	2
Garden flowers, herbaceous perennials		6" can	1

*Examples of names of plants within each group are given starting on page 164.

** 6" can equals approx. 1 gallon; 8", 2 gal.; 10", 5 gal.; and 1 peck, 4 gal.

Growing Surfaces

Container nursery stock grown on bare soil presents a number of problems. The roots may grow through the drainage holes into the soil upon which the containers have been placed. Rapidly growing weeds in the soil between the containers are difficult to control. In wet weather it is difficult to work

with plants that have been set on bare soil. In wet weather, the containers may fail to drain properly, causing many plant losses.

The least expensive solution to this problem is to place 2-mil black polyethylene sheets over carefully graded and smoothed soil. An herbicide, such as caseron, may be applied to the soil before the film is put in place. The containers are then placed on this film. Weeds will not grow under black polyethylene, roots stay in the pots, and mud is eliminated. The polyethylene film, however, disintegrates and must be replaced after each crop. Containers with smooth bottom outside surfaces sometimes will not drain properly when set on plactic film. The use of black plactic film is shown in Figure 106 on page 145.

Another, but costlier solution is to put down about 6 inches of crushed stone (½ to 3/4" diameter) over the black film and place the containers on this. This scheme has all of the advantages of the first solution, with the additional benefit of being permanent.

Figure 108. A crushed stone surface for growing container stock.

Where container stock is being handled in large quantities with pallets and fork lifts or wagons and tractors, it has been found worthwhile to pave the entire area with black asphalt in the same manner as a parking lot. Black asphalt paving is, however, the most costly practical growing surface for container stock.

Growing Medium

After appropriate containers have been selected, the next step is to prepare a suitable growing medium for the plants.

A growing medium for container-grown stock must satisfy the following general requirements:

1. Drain well
2. Hold moisture well

3. Be well aerated
4. Have an appropriate pH range (6.0 to 7.0)
5. Have an adequate reserve of plant nutrients
6. Be free of insects, diseases, weeds
7. Be readily available and easily duplicated
8. Not be too expensive
9. Plants grown in the growing medium must readily develop roots after planting

There is no standard soil mix for container-grown plants. Each nurseryman adopts and develops a mix best suited to his individual situation. A basic formula would be 1 part soil, 1 part sand, 1 part peat. Sawdust or bark are sometimes used in place of peat. The peat provides for good moisture retention while both the peat and sand provide good water drainage and aeration. If the soil used is a sandy loam, the amount of sand added to the mixture may be increased. Sawdust, ground corncobs, peanut hulls, and other locally available organic materials are sometimes substituted for part or all of the peat. Inclusion of a soil containing some clay is probably desirable because it serves as an excellent "blotter" for nutrients. Clay loam is often also included for another reason. Researchers have found that if the air spaces in the soil are too large, the plant roots are more easily damaged when the soil becomes frozen. In an indirect way, the inclusion of clay loam in the soil mix seems to reduce freeze injury to roots by reducing the size of the air spaces within the soil. Slow-release fertilizers such as "MAGAMP with K" and "OSMOCOTE" are often incorporated in these soil mixtures. Currently, nurserymen are using "MAGAMP with K" at ½ the rate recommended on the package.

The University of California has developed a "U.C. Mix" that has been used successfully by many nurserymen. It consists of equal parts of fine dune sand and finely shredded German peat and certain fertilizer materials. You may wish to read further about it in Reference number 46, The U.C. System for Producing Healthy Container-Grown Plants.

Weeds, insects, and disease organisms that are likely to be present in these mixtures are destroyed by steaming the medium for 30 minutes at 180°F. This is usually done on a concrete floor by injecting steam into

the mix under a plastic sheet that is heat and chemical resistant. The mix is often steamed on the bed of a dump truck, using the same technique. An existing greenhouse steam boiler or a portable steam boiler may be used as a source of steam. One important precaution is that slow-release fertilizers should not be incorporated into the growing medium until after steaming.

Some nurserymen use cement mixers for mixing soil. One nursery has found that a flail-type manure spreader may be used for rapid and economical mixing of the ingredients for a growing medium. Six cubic yards can be mixed in one minute by this method. Front-end loader scoops on tractors are useful in moving large quantities of soil mixtures from place to place.

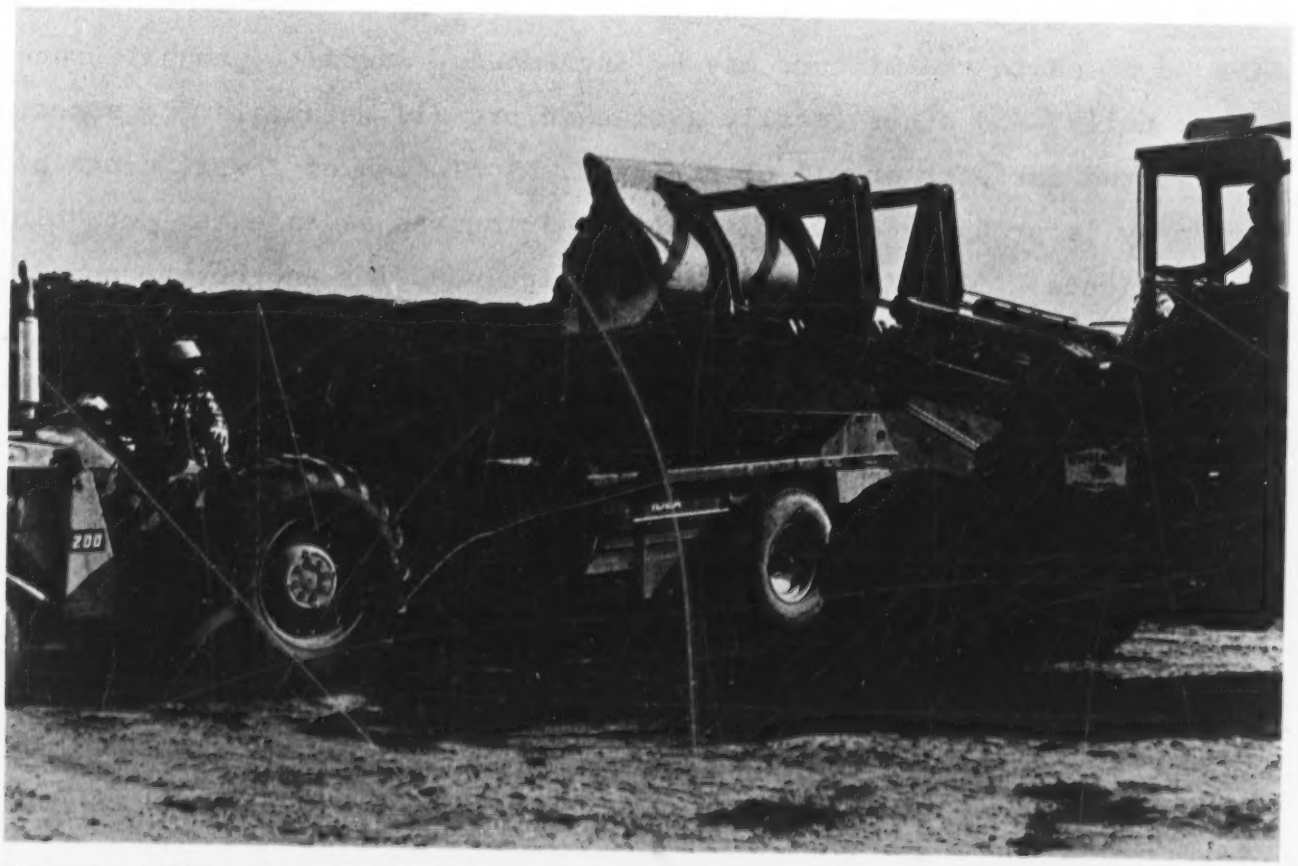


Figure 109 . A flail-type manure spreader may be used for mixing a growing medium.(Courtesy Conard-Pyle Co., West Grove, Penna.)

Because growing mixes that contain no soil are lighter in weight and more convenient to handle, they are often recommended for the growing of container nursery stock. Some nurserymen have found, however, that if the soil into which the plant is finally planted is too unlike the soil

in the container, the plant may not perform well when planted by the customer. For example, a plant that was grown in a container of sand and peat that is finally planted in a fairly heavy clay soil may fail to develop roots into the new soil. The original roots may continue growing only in the original sand and peat mixture. Some nurserymen feel that the inclusion of some clay loam soil in the original soil mixture helps to overcome this problem. The mixing of peat (and possibly some sand) in the backfill soil at the time of planting also encourages root growth outside the original soil ball. Some nurserymen also recommend that several cuts about 1" deep be made into the sides of the soil ball when the shrub is planted. This root pruning encourages rapid development of new roots.

If the nurseryman anticipates that the plants will finally be planted in a soil no heavier than a clay loam having good structure, he may wish to use a 1 to 1 ratio of sand and peat as a growing medium. This mixture holds moisture in the same manner as a good clay loam, and root growth into the surrounding soil should be satisfactory.

Planting

Container nursery stock is usually planted by hand using rooted cuttings, one year old seedlings, dormant unrooted cuttings, dormant grafts, or plants previously grown in small pots. Planting is usually done in early spring. Many nurseries purchase these plants, but some propagate their own. Certain plants, such as firethorn and azalea, may have been grown in small pots before they are planted in these larger containers. The plants are placed in the center of the container, at the depth at which they originally grew and the growing medium is firmed around the roots to assure good contact. The container is filled to within ½ to 3/4 inch of the rim to leave a space that accumulates water when the plants are watered.

Most nurseries devise an assembly-line system so that the potting operation can be done efficiently. Usually there are separate crews, each filling pots, moving in the plants to be potted, potting the plants, loading the planted plants, and moving them to the growing

area where they are set in place, and finally a watering crew that waters them as soon as they are in place. Semiautomatic potting machines are being developed to speed this operation.

It has been found that a 5 man crew is able to plant nursery stock in containers, put them in place in the beds, and water them at the rate of 5000 to 7000 per day provided the procedure is well planned. The same crew can do up to 12,000 per day once they become used to the technique. A plan that works well is to place the empty containers on a flatbed truck or wagon, fill them with the growing medium, have two men making planting holes, two planting and putting the plants into the beds, and one watering them. This is done while the truck or wagon is slowing moved (with frequent stops) down the row between 2 planting beds.

Figure 110 . Container-grown roses are planted as dormant large plants in early spring and sold in leaf several months later.

You may wish to read further details on the mechanization of handling container stock in "A balance -- men, machines, and practices," Section II and "Mechanization," Section IV in Nursery Management Handbook, Reference 28.

Watering

An adequate water supply of good quality that is available in large volume is necessary for the production of container-grown nursery stock. A 1 gallon size container will require 1 pint of water at each watering. It has been estimated that one acre of container stock may require a much as 40,000 gallons of water per day at a flow rate of 300 g.p.m. (gallons per minute).

The quality of the water is also important. Water from deep wells may have a salt content that is too high (a Sol-U-Bridge reading above 200 MHOS$\times 10^{-5}$).

Water from a stream could contain chromium from a plating plant or boron from a laundry in high enough amounts to cause trouble. Water from any proposed source should be analyzed before it is used.

The nursery foreman usually examines individual plants in each block several times a day to determine whether watering is required. If the soil surface has become dry to the touch, the plants are watered at once with sufficient water to allow a slight excess to flow out the drainage holes in the containers.

The frequency of watering can vary from twice a day on a hot summer day, to once a week in fall and spring, to none at all while the soil is frozen in mid winter.

Factors that determine how frequently the plants will require water are:

1. The kind of growing medium
2. Whether the soil surface in the container has been mulched
3. The volume of the container
4. The material of which the container is composed
5. The size of the plants
6. The kind of plant (deciduous, needle evergreen, broadleaved evergreen)
7. Season (plants dormant or growing)
8. Weather (rainy, dry, hot, cold, windy, calm)

Container nursery stock is usually arranged in blocks of plants that will dry at the same rate, so they will all require water at the same time. This makes the use of semiautomatic irrigation equipment practical. Such plants must be uniform in species, size container, growing medium, and plant size (age). Needle evergreens generally require less frequent applications of water than broadleaved plants.

Semi-automatic watering systems are used for watering container nursery stock because hand watering is not economical. These systems also aid in the production of uniform quality plants because exactly the same amount of water is applied to each plant. Dilute fertilizer solutions may also be applied at a uniform rate through semiautomatic watering systems. The application of fertilizer by this method eliminates costly hand application of fertilizer.

A number of different kinds of semiautomatic watering systems for container nursery stock are in use.

One large midwestern nursery uses a portable system involving rotating sprinkler heads mounted on standpipes. Each head can water an area of about 10,000 square feet.

Watering is often done with portable aluminum irrigation pipe laid on the surface of the soil along the edges of every 4th bed, or in such a manner that sprinklers on 3 foot risers are spaced about 21 feet apart in the whole area in which the container plants are being grown. In some cases the Skinner method, which consists of an automatically rotated pipe on which long-throw spray nozzles are mounted, is mounted about 7 feet high, in rows about 80 feet apart throughout the area. Another method is one in which small plastic tubes convey the water to each container individually. This last method is especially useful where conservation of water must be considered. It also assures that each container receives the same quantity of water. Daily inspection to make sure that all tubes are functioning is necessary with this system. In Figure 111, page 157, The small plastic tubes, with attached lead weights may be seen in the upper left in the photograph.

Figure 111 illustrates an automatic watering system set up for producing large trees or shrubs in 15-gallon containers in a California nursery. All pipe is of polyvinyl chloride plastic. The size of the supply line is reduced at intervals from the main in order to maintain even flow rates at all points in the system. A Gates plastic nozzle, giving a flat spray pattern in a quarter-circle pattern, is mounted at the end of each 1/8" plastic tube. It is held in place in a small hole drilled at a 60^{o}angle in a 1"x1" wooden stake. The stake is driven into the soil at the edge of each container. The containers are spaced on 4-foot centers on a graded area covered with 2" of crushed stone. The water pressure is 25 P.S.I. The system is operated for 5 minutes, delivering about 2 gallons of water at each watering. Watering is done about every 3 days; more frequently in exceptionally hot or windy weather.

A large eastern nursery arranges water mains between every other row of plants, with small plastic tubes to the plants on each side of the main. This leaves alternate rows clear for workers who can prune or do other work without interruption while the plants are being watered. Over 250,000 two gallon containers are watered by this method.

Another watering system extensively used by a California nursery involves the use of a special on-off weight at the end of the plastic tube placed in each container. Each tube automatically stops delivering water when the container is removed. This conserves water and eliminates hand watering of partially cleared blocks of plants.

You may wish to read about watering systems for container stock in greater detail in Reference 5, Automatic Watering.

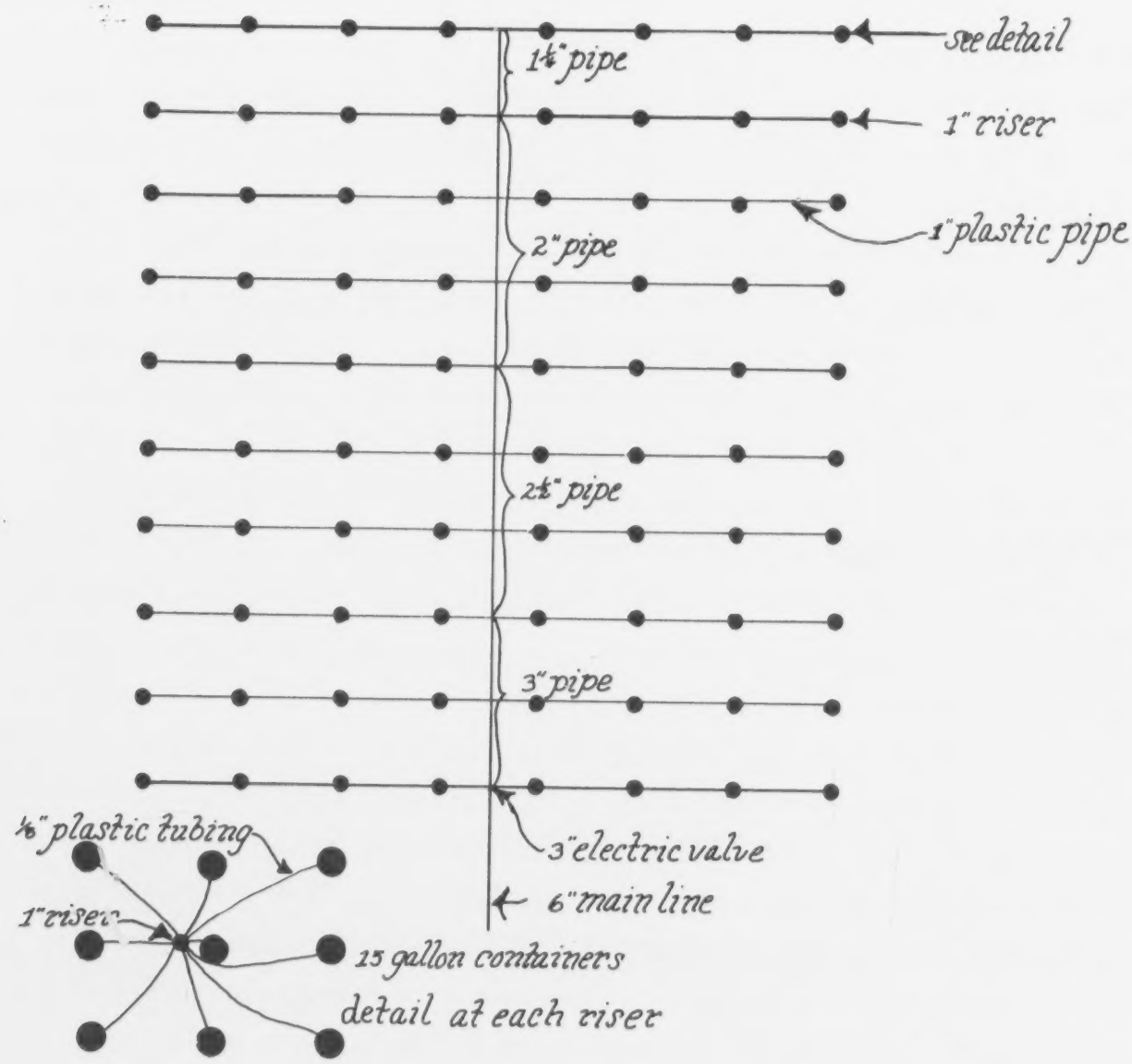


Figure 111. Irrigation system for container stock at Oki Nursery, Riverside, Calif.

Fertilizer Application

Although fertilizer usually has been incorporated into the soil mixture in which container-grown nursery stock is planted, additional fertilizer is needed as the plants grow. Container-grown nursery stock requires more careful fertilizing than field-grown stock because the soil volume is relatively small and the plants use the nutrients at a rapid rate. For rapid, vigorous growth, the plants must have a nonfluctuating supply of nutrients at all times. The fertilizer may be applied in dry or liquid form at long intervals, or it maybe applied in very dilute form at every watering.

For dry applications, a 10-10-10 analysis may be used, and 1 level teaspoonful is applied to each 1-gallon container each month in April, May, June, and July. A 2 gallon container would receive 2 level teaspoonsful; a 3 gallon container, 1 tablespoonful at each application.

Some nurseries use a 12-6-6 analysis fertilizer, with a ureaformaldehyde nitrogen carrier, at the rate of 12 pounds per 300 sq. ft. simply broadcast as evenly as possible over the plants when they are in containers that are "pot tight." When these plants have grown enough so that they are spaced out to allow room for lateral growth, this fertilizer is applied at the rate of 1 teaspoonful per container. No fertilizer is applied in August in order to reduce the possibility of soft growth in the fall which is easily winter killed. The growing medium should be moist at the time of application, and the plants should be watered immediately after the fertilizer has been applied. Applying fertilizer in this way is a laborious operation. Application of soluble fertilizers through the irrigation lines requires considerably less labor. Concentrated applications may be made at 2 week intervals; less-concentrated applications at 5 day intervals; or very dilute solutions may be used each time the plants are watered.

The applications to be made in concentrated form at 2 week intervals usually involve a 20-20-20 or 15-15-15 analysis soluble fertilizer applied at the rate of ½ ounce per gallon of water applied to the plants. In the special case of rhododendrons, a 10-40-10 or similar ratio fertilizer analysis is used in July and early August because it gives better growth and

heavier flowering. Just as in dry applications, the soil must be moist before application. This concentrated solution will severely burn foliage, so the leaves must be sprinkled with clear water immediately after application to avoid this injury. Fertilizer applied in this way is usually diluted in water in large mixing tanks and pumped through the watering lines. A blue or green dye is usually added to the solution so the fertilizer-bearing water may be easily identified. These applications at 2-week intervals are discontinued after mid-August to avoid soft growth which winter kills easily.

Continuous fertilization by adding small quantities of fertilizer to the irrigation water is probably the ideal way to supply nutrients to container nursery stock. It involves the use of very precise injection devices similar to the type for injecting chlorine into drinking water. Several models of injectors with different dilution rates are used. The following table indicates the appropriate amount of fertilizer to be used in the concentrated solution. The rates in this table will give about 75 ppm of N in the irrigation water.

Table 10 Injection ratios and concentrations for continuous fertilization of container nursery stock.

Injector Ratio	Ounces of 20-20-20 per Gallon of Concentrate
1:300	21
1:200	12
1:100	5
1: 50	2

The nurseryman observes the growth of his plants carefully, and during periods of rapid growth if leaf size and color indicate a need for increased nutrients, he may increase the amount of fertilizer in the concentrated solution for a week or two. If chlorosis (yellowing of the leaves) occurs in plants he should take a plant tissue sample and have it analyzed to determine whether certain trace elements such as iron or magnesium are lacking. Many other things, such as disease, poor soil drainage, and wrong pH level, can also cause chlorosis in plants. These possibilities should also be

considered. Trace elements can be added to the concentrated solution if tests indicate that they are needed.

With a continuous fertilizing program, the nutrient levels should be lowered by September to avoid soft growth that might be injured during the winter. You may wish to read pages 20 and 21 in Reference 31. Plantainer Growing, for additional information on fertilizing container nursery stock.

Pruning

Container nursery stock is pruned in order to improve the shape of the plant and to give compact growth.

Vines, groundcover plants, and certain plants with a compact habit are usually not pruned.

Plants with a single main trunk, such as upright junipers, taxus, pines, spruces, and hemlock are allowed to develop a central leader which is not pruned. Long side shoots may be cut back to half their original length in July to encourage compact growth. In the special case of pines, the longer new side shoots, "candles," are cut back to half their length in June before the needle leaves have expanded. If this is done too late, the cut-shoots of pines will fail to develop new branch shoots.

Plants to be grown without a single main trunk are usually pruned at the time that they are planted in the containers. Each spring thereafter, the longer shoots on these plants are cut back to half their original length before new growth starts. To distribute the work load in a nursery, this pruning is often done in late fall and winter while the plants are dormant, instead of in the spring.

Shearing is sometimes done to achieve a formal shape with dense-growing plants such as boxwood.

Figure 112 . Staked Firethorn (Pyracantha) in 1 gallon cans.

Supporting

Container-grown vines (unless to be used as groundcovers) are tied to wooden or bamboo stakes to support them in an upright position. Stakes from 2 to 3 feet long are used for this purpose. Firethorn (Pyracantha coccinea) intended to be used as espaliers are also tied to stakes.

Controlling Plant Pests and Diseases

The first step in controlling insects and diseases was explained in the section on growing mediums. The steaming of these mixes helps to eliminate weeds, insects, and diseases from the growing medium.

The second step is careful examination of the planting stock. If the roots have a "knobby" appearance they should be carefully examined by an entomologist for possible infection by root-knot nemas. If such pests are present, the stock should be destroyed. If evidence of grubs is found, the soil should be drenched with the appropriate chemical after planting. If evidence of aphids, spider mites, or eggs or pupae of other insects is found in the leaves, the plants should be sprayed after planting. Plants with rotted roots or stems should be destroyed, and an appropriate fungicide applied to the remaining plants.

During the growing season, all persons working with the plants must constantly be looking for evidence of insect and disease damage.

If these problems are not controlled when they first develop, poor quality or unsaleable crops may result. Figure 84 on page 124 illustrates a truck-mounted sprayer used for spraying nursery plants.

Diseases and Pests of Ornamental Plants (Reference 12) is a very

useful reference for identification of organisms that are pathogenic to nursery crops.

Because new pest control materials are introduced each year and the federal and state regulations governing their use are changed from time to time, it is suggested that you consult current issues of Recommended Insecticides and Miticides (Reference 37), Fungicides and Nematicides (Ref. 18) as well as similar extension publication for your state.

Winter Protection

Wide fluctuations in temperature of the growing medium as well as the foliage (in the case of evergreens) may severely damage or kill container-grown nursery stock during winter. During winter months, protection against animal damage is also important.

With all container stock the primary winter problem is that of preventing wide temperature fluctuations in the growing medium. A common way to overcome this problem is to move the plants close together and surround each block of plants with snow fencing. A light mulch of straw (free of weed seeds) is then placed around the plants and over the tops.

Evergreens, both needle and broadleaved, are most successfully wintered under covers of polyethylene. Some nurseries grow their container plants in beds under greenhouse-like structures. These structures are covered with 2-mil polyethylene film in mid to late fall as shown in Figure 113. One nursery, as shown in Figure 113, makes shallow basins in the walks with black polyethylene film. These basins are flooded with water in early winter and allowed to freeze. This ice acts as a natural thermostat--keeping the house cool during midwinter and early spring thaws. On bright days in early spring these polyethylene houses must be carefully ventilated to prevent overheating. High temperatures may start the plants growing too early, and a sudden hard freeze late in the season may severely damage them.

Rabbits and mice can destroy entire blocks of certain species over

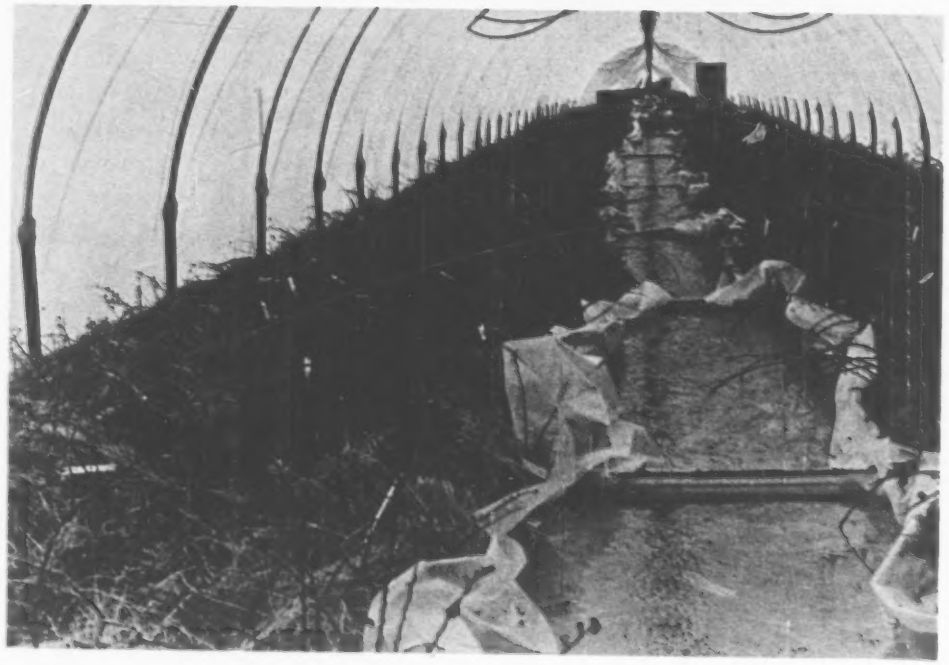


Figure 113. Winter protection for container nursery stock.

Upper left: Applying polyethylene film to framework over beds.

Upper right: A field of container stock covered for the winter.

Lower left: Walks between beds flooded with water which freezes and thaws to prevent wide temperature fluctuations.

(Courtesy Conard-Pyle Co., West Grove, Penna.)

winter by eating either the bark or the entire plant when their supply of natural food has become scarce. They have a preference for Pyracantha, Cotoneaster, Rhododendron, Crabapple, Cherry, Plum, and Winged Euonymus, but will often damage Taxus and Junipers. Poison baits are often used for controlling them, but they must be used in such a way as not to be hazardous to children, pets, or desirable wildlife.

Harvesting

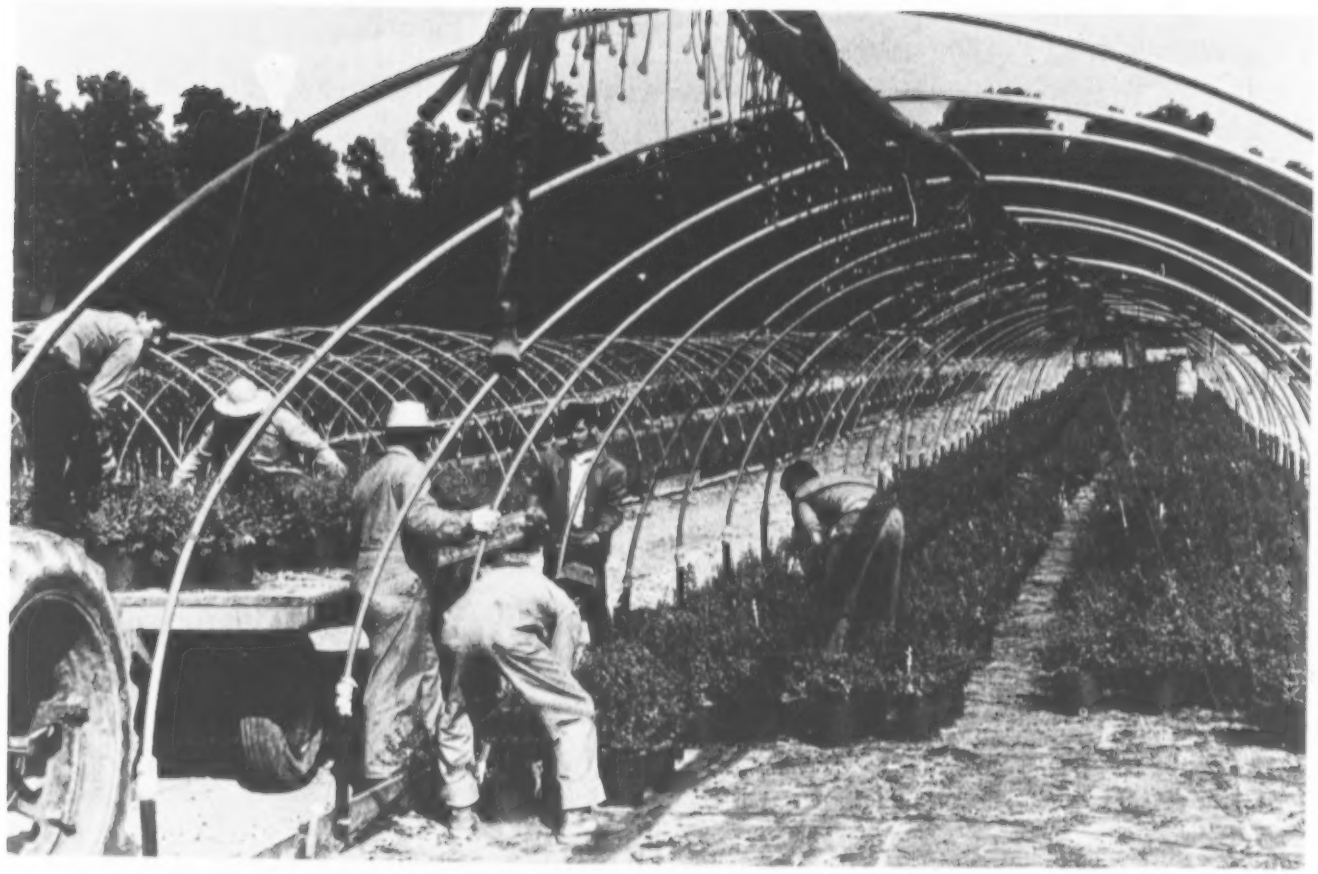
Container-grown nursery stock is ready to be sold when it has reached an appropriate size for the container. Table 9 in the section on Crop Schedules, page 148, indicates the usual time it takes to grow this stock to saleable size. Sorting the stock into groups by grade is a time and labor consuming operation. Standard grades for container nursery stock are given in detail at the end of each section in Reference number 48, USA Standard for Nursery Stock. Each plant must be moved, examined, and labeled.

One important limitation on container-grown stock is that it cannot be carried through an additional year in the same container. If this is attempted, the plants when finally sold and planted will perform poorly because the root system will have developed into a heavy tight spiral around the inside wall of the container, and new root growth into the soil surrounding that spiral will be very slow.

Container-grown nursery plants are sold in large quantities in early spring and in the fall. Actually, both container-grown and B&B stock can be successfully planted at any time that the soil is not frozen, but most customers prefer to plant in spring and early fall. This planting tradition came about because deciduous field stock is usually transplanted at these times.

List of Nursery Plants Commonly Grown in Containers

Many nursery plants may be successfully grown in containers, and possibly in the future nearly all of them will be. The following list



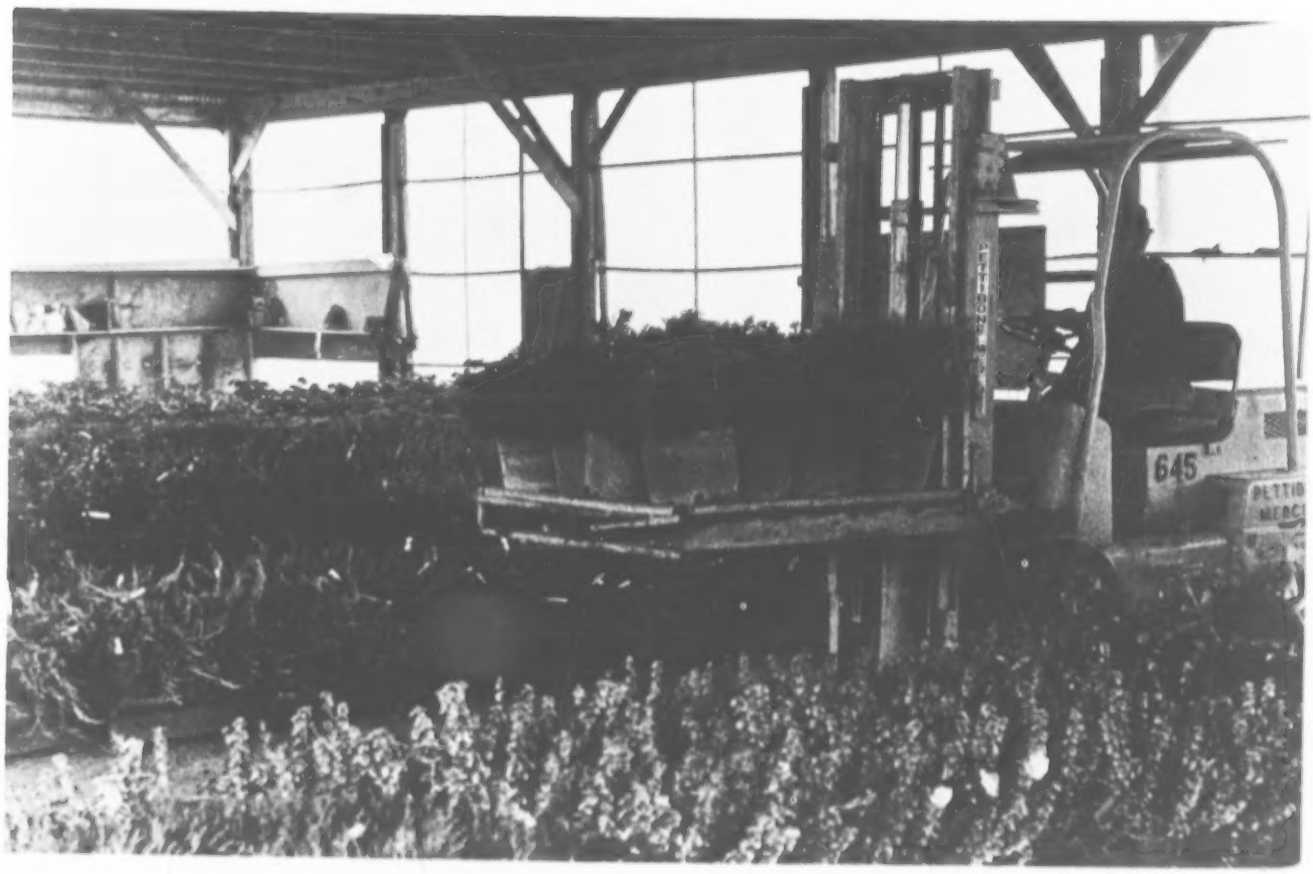


Figure 114. Harvesting container nursery stock.
Upper: Moving Wintergreen Barberry plants to a flatbed wagon.
Lower: Moving Mugho Pines with a fork lift.
(Courtesy Conard-Pyle Co., West Grove, Penna.)

includes only the plants commonly grown in containers at the present time. A few nurseries now grow flowering crabapples, flowering cherries, and flowering plums, as grafted or budded plants, for 1 to 3 years in 5 gallon containers and market them as 5-6',6-8', or 8-10' plants. Good quality yews are very difficult to produce as container-grown stock, so they are seldom attempted.

Common Name	Technical Name
A. Small Deciduous Trees	
1. Bloodleaf Japanese Maple	Acer Palmatum 'Atropupureum'
B. Evergreen Trees	
1. Sawara Falsecypress	Chamaecyparis pisifera
2. American Holly	Ilex opaca
3. Red Cedar	Juniperus virginiana
4. Koster Blue Spruce	Picea pungens 'Glauca Koster'
5. Canada Hemlock	Tsuga canadensis
C. Narrowleaf Evergreen Shrubs	
1. Slender Hinoki Falsecypress	Chamaecyparis obtusa 'Gracilis'
2. Pfitzer Juniper	Juniperus chinensis 'Pfitzeriana'
3. Creeping Juniper	Juniperus horizontalis
4. Andorra Juniper	Juniperus horizontalis 'Plumosa'
5. Dwarf Mugho Pine	Pinus mugo
6. "Ware's" Arborvitae	Thyja occidentalis 'Wareana'
D. Large Broadleaf Evergreen Shrubs	
1. Japanese Aucuba	Aucuba japonica
2. Common Box	Buxus sempervirens
3. Common Camellia	Camellia japonica
4. Evergreen Euonymus	Euonymus japonica
5. American Holly	Ilex opaca
6. Chinese Photinia	Photinia serrulata
7. Rose Bay Rhododendron	Rhododendron cultivars

E. Medium Deciduous Shrubs	
1. Mentor Barberry	Berberis mentorensis
2. Japanese Barberry	Berberis thunbergi
3. Red Osier Dogwood	Cornus stolonifera
4. Spreading Cotoneaster	Cotoneaster divaricata
5. Winged Euonymus	Euonymus alatus
6. Forsythia, "Lynwood Gold," "Spring Glory," "Beatrix Farrand"	Forsythia intermedia 'Spectabilis'
7. Beautybush	Kolkwitzia amabilis
8. Winter Honeysuckle	Lonicera fragrantissima
9. Northern Bayberry	Myrica pensylvanica
10. Flame Azalea	Rhododendron calendulaceum
F. Medium, Broadleaf Evergreen Shrubs	
1. Japanese Aucuba	Aucuba japonica
2. Wintergreen Barberry	Berberis julianae
3. Evergreen Euonymus	Euonymus japonica
4. Spreading Euonymus	Euonymus kiautschovicus
5. Convex-Leaf Japanese Holly	Ilex crenata convexa
6. Burford Chinese Holly	Ilex cornuta 'Burfordi'
7. Japanese Pieris	Pieris japonica
8. Laland Firethorn	Pyracantha coccinea 'Lalandi'
G. Small Deciduous Shrubs	
1. Rockspray Cotoneaster	Cotoneaster horizontalis
2. Dwarf Winged Euonymus	Euonymus alata 'Compacta'
3. Tree Peony	Paeonia suffruticosa
4. Mollis Azalea	Rhododendron kosterianum
5. Exbury Azalea	Rhododendron hybrid
6. "Anthony Waterer" Spirea	Spirea bumalda 'Anthony Waterer'
7. Dwarf European Cranberrybush	Viburnum opulus nanum
8. "Bristol Ruby" Weigila	Weigela 'Bristol Ruby'

H. Small, Broadleaf Evergreen Shrubs

1.	Glossy Abelia	Abelia grandiflora
2.	Korean Littleleaf Box	Buxus microphylla 'Koreana'
3.	Rose Daphne	Daphne cneorum
4.	Somerset Daphne	Daphne somerset
5.	Bigleaf Wintercreeper Euonymus	Euonymus fortunei vegetus
6.	Evergreen Candytuft	Iberis sempervirens
7.	Convex-Leaf Japanese Holly	Ilex crenata convexa
8.	Drooping Leucothoe	Leucothoe catesbaei
9.	Box Honeysuckle	Lonicera nitida
10.	Oregon Holly Grape	Mahonia aquifolium
11.	Carolina Rhododendron	Rhododendron carolinianum
12.	Catawba Rhododendron Hybrids "P.J.M." and "Purple Gem"	Rhododendron catawbiense hybrids
13.	Hybrid Azalea	Rhododendron hybrid
14.	Korean Rhododendron	Rhododendron mucronulatum
15.	Snow Azalea	Rhododendron mucronatum
16.	Amoena Azalea	Rhododendron obtusa amoena
17.	Torch Azalea	Rhododendron amoenum
18.	Korean Yodogawa Azalea	Rhododendron poukhanense 'Yedoense'
19.	Reeves Skimmia	Skimmia reevesiana

I. Deciduous and Evergreen Vines

1.	Five-Leaf Akebia	Akebia quinata
2.	European Bittersweet	Celastrus orbiculatus
3.	Clematis	Clematis hybrids
4.	Sweet Autumn Clematis	Clematis paniculata
5.	Bigleaf Wintercreeper Euonymus	Euonymus fortunei 'Vegata'
6.	Algerian Ivy	Hedera canariensis
7.	English Ivy	Hedera helix 'Baltica'
8.	Climbing Hydrangea	Hydrangea petiolaris
9.	Japanese Wisteria	Wisteria floribunda
10.	Chinese Wisteria	Wisteria sinensis

J. Deciduous and Evergreen Groundcovers

1.	Creeping Cotoneaster	Cotoneaster adpressa
2.	Bearberry Cotoneaster	Cotoneaster dammeri
3.	Rockspray Cotoneaster	Cotoneaster horizontalis
4.	Baltic English Ivy	Hedera helix 'Baltica'
5.	Bar Harbor Juniper	Juniperus horizontalis 'Bar Harbor'
6.	Creeping Juniper	Juniperus horizontalis
7.	Green Carpet Juniper	Juniperus chinensis 'Wiltoni'
8.	Sargent Juniper	Juniperus chinensis 'Sargenti'
9.	Japanese Spurge	Pachysandra terminalis

K. Garden Flowers, Herbaceous Perennials

1.	Butterfly Weed	Asclepias tuberosa
2.	Astilbe	Astilbe hybrids
3.	Garden Chrysanthemum	Chrysanthemum morifolium
4.	Delphinium	Delphinium hybrid (esp. D. belladonna h.)
5.	Bleeding Heart	Dicentra spectabilis
6.	Daylily	Hemerocallis hybrids
7.	Evergreen Candytuft	Iberis sempervirens
8.	True Lavender	Lavendula vera (esp. 'Munstead')
9.	Peony	Paeonia hybrids
10.	Oriental Poppy	Papaver orientale

SUGGESTIONS AND REFERENCES FOR THE TEACHER

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Suggested Learning Activities

1. Arrange for a class field trip to several nurseries where container-grown stock is produced.
2. During the visits, identify plants that are grown in containers.
3. Observe the spacing used for container stock, and the kinds and sizes of containers used for growing them.
4. Plant a container crop in the school nursery, (see p. 42-46, 65, in "Developing a High School Program in Ornamental Horticulture." Vol. I Nursery Management, Reference 12.
5. Provide students with experience in pruning and training container stock.
6. Give students experience in watering and fertilizing container stock.
7. Arrange for the class to interview from 3 to 5 nurserymen.
8. Have students grade several crops of container stock, and correctly label them in preparation for marketing, (see USA Standard for Nursery Stock and A Checklist of Woody Ornamental Plants of California.)
9. Have students observe the loading of container stock into trucks for long distance shipment.
10. Have the students construct an appropriate shelter for winter protection of container stock growing in the school nursery.
11. Work with the students in the development of a crop succession schedule for container stock in the school nursery.

Test

1. What is meant by "container stock"?
2. List the advantages and disadvantages of growing nursery stock in containers as contrasted to growing them in fields.
3. List the things to be considered in selecting an appropriate kind of container for nursery stock.
4. Give some examples of growing mediums that are suitable for growing container stock.
5. What things must be considered in selecting the kind of surface upon which the container plants will be placed?

6. Describe a suitable fertilizing program for container stock.
7. By means of a labeled sketch, indicate a method for watering container nursery stock.
8. What happens if container plants are placed too close together in the growing area?
9. At what time of the year is container stock planted? Why?
10. What overwintering protection must be given to container stock?
11. Why is there a limit to the length of time a nursery plant can be grown in a container?
12. Name at least 10 kinds of nursery plants that are commonly grown in containers.

CHAPTER 8

MARKETING

Learning Objectives

1. To learn the procedures in shipping nursery stock.
2. To learn the factors to consider in pricing nursery stock.
3. To learn effective ways of advertising nursery stock.
4. To learn how to store nursery stock properly in preparation for marketing it.
5. To learn how to grade nursery stock.
6. To learn the procedures in marketing bare-root, balled and burlapped, and container stock.
7. To become aware of federal and state plant quarantine laws.

Key Questions

1. What advertising methods are used by wholesale nurseries?
2. What is inventory control of nursery stock?
3. How does a nursery determine prices for its products?
4. What are the advantages of standard grades for nursery stock?
5. Why is the proper labeling of plant material important?
6. How are B&B, bare-root, and container nursery plants packed and shipped?
7. Why are there federal and state plant quarantine laws?

Key Words

Advertisement - a notice, usually printed, offering products for sale
Burlap - a coarse cloth which may be made of jute, flax, or hemp
Fumigation - killing harmful organisms by gas, smoke, or vapor
Grading - to classify according to quality, rank, or worth
Promotion - creating interest in a business to increase sales
Promotion - creating interest in a business to increase sales

Quarantine - the restriction or isolation on travel or passage which is enforced by the government to prevent the spread of plant pests and diseases

Regulated areas - geographical areas which are considered infested by pests

Regulated articles - commodities, equipment, and transportation facilities known to be pest carriers or items that might spread the pest

Scion wood - wood with shoot or bud used as propagating material

Marketing

"Nothing happens until the product is sold," is a marketing phrase that is often quoted. It is true that the income upon which a nursery depends for its operation is derived from the plants it sells. Marketing the plants, then, is a most important step in the nursery business operation.

This section is intended to acquaint you with how nursery crops are marketed so that you may see how your activities and skills are related to it. The channels through which nursery products are marketed wholesale, the nursery salesman, the nursery sales agent (or representative), and the nursery jobber, are described in detail on pages 7 and 8 in Chapter 1, "Kinds of Nurseries."

Advertising and Promotion

Wholesale nurseries advertise in trade journals, by distributing wholesale catalogs to current and prospective customers, and through salesmen who call on customers or prospective customers to offer their stock and services.

Wholesale price lists are distributed at the beginning of each year. These list the plants offered in an alphabetical arrangement by technical names. The grades available, together with quantity prices are also given. An example is shown in Figure 99, page 140.

The display grounds, see Figure 13 page 41, are useful to customers calling at the nursery. Customers may observe mature specimens of the smaller plants offered for sale.

The American Association of Nurserymen provides national promotional activities for the nursery business in trade journals and garden magazines having wide distribution.

Many wholesale nurseries promote their products with display booths at state and national meetings of nurserymen.

Needless to say, retail nurseries advertise their products to the final consumer in an even greater variety of ways and aim the advertising at a more localized area.

Inventory Control

As nearly as possible, a wholesale nursery must have stock on hand ready to sell:

a. of the kinds of plants the customers want,

b. in the grades and sizes required,

c. at the time the customer wants to buy.

Each year the nurseryman and his managers must pool their information on market trends, what kinds of plants have or have not sold well in the past season, "short" items, "long" items, the sizes needed, and any changes in the time of purchases. The information is then evaluated to plan the kinds, sizes and quantities to propagate, grow, harvest and offer for sale. Because some kinds of woody plants require 7 or more years to reach marketable size, this kind of decision making could be referred to as long range planning.

To provide an idea of the relative quantities of kinds of nursery stock sold each year, see Table 11, "Quantities of 70 kinds of nursery stock for sale in Pennsylvania in 1970." This list may give an idea, in a general way, of the relative quantities of stock sold by an individual wholesale nursery. The number of White Firs offered for sale is unusually high and probably represents a specialist crop, largely marketed outside of Pennsylvania.

Table 11. Quantities of 70 kinds of nursery stock for sale in Pennsylvania in 1970 (from Ref. 8 1970 Buyers Guide for Pennsylvania Nursery Stock. Department of Agriculture, Commonwealth of Pennsylvania, Harrisburg, Pa. 1970)

Name	Quantity
White Fir	60,335,247
Japanese Maple	19,335
Norway Maple	92,051
Red Maple	72,786
Sugar Maple	24,495
Shadblow	31,535
Azalea-Exbury Hybrid	23,941
Azalea-Mollis Hybrid	19,093
Azalea-obtusum Hybrid	60,023
Azalea-Gable Hybrid	37,052
Japanese Barberry	88,637
Paper Birch	34,310
European W. Birch	170,808
Common Boxwood	22,329
Flowering Dogwood	124,084
Crown Vetch	383,000
Autumn Elaeagnus	22,794
Winged Euonymus	45,634
Purple Wintercreeper	205,900
Euonymus-Emerald	28,640
Wintercreeper	78,625
Forsythia	26,557
Green Ash	22,818
Honeylocust	18,252
English Ivy	1,730,000
Japanese Holly	75,062
Creeping Juniper	47,588
Andorra Juniper	24,433
Ibolium Privet	35,135
Sweet Gum	38,121
Crabapple	148,502
Japanese Spurge	1,756,600
Norway Spruce	601,385
White Spruce	319,174

Name	Quantity
Dwarf Alberta Spruce	25,104
Black Hills Spruce	231,611
Serbian Spruce	92,925
Colorado Spruce	752,080
Blue Colorado Spruce	420,380
Japanese Andromeda	38,703
Mugho Pine	265,228
Austrian Pine	342,574
Red Pine	325,567
White Pine	863,810
Scotch Pine	1,353,750
Japanese Black Pine	176,235
Douglas Fir	1,393,112
Laland Firethorn	43,664
Northern Red Oak	625,334
Pin Oak	96,861
Catawba Rhododendron	21,927
Rhododendron Hybrid	199,164
Rosebay Rhododendron	19,272
Multiflora Rose	183,075
Spreading English Yew	30,837
Japanese Spreading Yew	177,532
Upright Japanese Yew	555,632
Intermedia Yew	165,209
Brown's Yew	175,344
Anglojap Yew	170,284
Dense Yew	116,714
Hatfield Yew	48,764
Hicks Yew	102,180
American Arborvitae	243,535
Globe Arborvitae	55,928
Dark Green American Arborvitae	39,369
Pyramidal Arborvitae	70,451
Canada Hemlock	635,955
Myrtle	615,000
Bowles Myrtle	57,300

The stock man is responsible for maintaining a current inventory (count) of all stock available for sale. This could be called short range inventory control. He does this by the use of stock index cards. Each card indicates the name of the plant, the grades or sizes, and the quantity on hand for sale in each size. Immediately after a sale is made, the stock index card for each kind of plant is brought up to date by subtracting the quantity sold from the number of plants on hand. Thus at any moment the number of plants still available for sale is known. If the quantity on hand falls below the anticipated sales, the stock man recommends to the business manager that additional plants be purchased from another nursery to fill the anticipated need. If it is not possible to do this, then the salesmen must be alerted to the fact that the particular plant is in short supply.

The records maintained by the stock man are called a "running inventory." These records may also be used later to give peak sales periods and items in short or long supply--information that is helpful in long-range planning.

Pricing

Wholesale prices for nursery stock do not fluctuate much in the course of a single season. Near the beginning of each year, usually in late December, wholesale nurseries distribute catalogs which give the kinds, grades and prices of the stock being offered for sale. The prices must be determined prior to the printing of the catalogue. Prices are based on 3 things: the cost of production; the supply in relation to the estimated demand; and the price for which the item sold the previous season.

The cost of production includes 3 things: overhead costs; direct costs; and marketing costs.

Overhead costs include all general costs of operating the nursery, such as taxes, depreciation, interest, rent, utilities, insurance, maintenance and repair, new construction of the physical plant, new equipment, supplies, managerial and administrative salaries, and labor wages that cannot be assigned to a particular crop. In applying this total overhead cost to the cost of production, the overhead cost is divided among the crops on a percentage basis.

Direct costs are costs that can be assigned to a particular crop. They include such things as the cost of seeds, rooted cuttings and liners that have been purchased, or the cost of producing the same items if the nursery collects its own seeds or propagates its own plants. Additional direct cost items are: labor and materials used in planting, weeding, fertilizing, pruning, watering, controlling pests, harvesting, grading, labeling, and storing the particular crop. If the plant being marketed happens to be a patented plant, a royalty (fee) for each plant sold must be paid to the holder of the patent. This royalty is added to the other costs in establishing the selling price.

Preparation and marketing costs, which also must be included in the selling price, involve the labor and materials used in assembling the plants in packing, selling costs, loading and freight or trucking charges. Marketing costs may represent from 10 to 15 percent or more of the cost of production.

Each year, before the catalog is printed, the business manager assembles all of the necessary information for determining what price will be charged for each item listed in the catalog.

If you are interested in costs of production, you may wish to read Reference 30, Operating Cost Study, and Reference 38, "Record Keeping and Data Acquisition," Section 12 in Nursery Management Handbook.

Standard Grades

The American Association of Nurserymen, Inc., has adopted uniform grading standards to classify the various plants handled by nurserymen. The methods and standards used are published in Reference 48, USA Standard for Nursery Stock, 1969 edition, by the American Association of Nurserymen.

Nursery stock is usually graded as it is placed in cold storage, however, B&B stock is graded in the field, often before it is dug. Container-grown stock is usually sorted into grades as it is being moved from the growing area to the shipping area. For these reasons, a discussion of grades is given on page 103 in Chapter 6 - Growing Nursery Stock in the Field and page 143 in Chapter 7 - Growing Nursery Stock in Containers. Specific details, which are somewhat complicated, are best obtained from Reference 48, USA Standard for Nursery Stock.

Marketing of standard graded nursery stock is easier than the marketing of stock that does not conform to standard grades. Both the seller and the buyer have a clear understanding of what the material is represented to be. Buyers now make most purchases by telephone, rather than by personal selection of the material at the nursery, which makes for faster and easier marketing. Telephone purchasing also indicates the confidence that buyers have in the stock being sold under standard grades.

Labeling

To assure the proper identification of plants being sold, each plant, or in cases of bundles of bare-root plants, each unit, is labeled. Although many nursery employees can identify most of the plants without the need of labels, many employees cannot. Also, different cultivars of some plants, roses for example, are virtually impossible to identify in the dormant condition. To avoid mixing plants while they are being handled in the nursery, and to assure that purchasers are able to identify the plants when they are received, all plants are identified by name. Technical names and cultivar names are used to avoid the confusion of duplicate common names. Abbreviations are often used when the genus or species is readily recognized. T. cusp. "Hicks," for example, means Taxus cuspidata "Hicks." The grade or size is also often indicated on the label.

Labels are usually attached to the plants as they arrive at the storage or shipping area. Wooden labels with printed names are frequently used. These are fastened to the plants with short pieces of wire. Printed plastic or metal labels are also being used. Some nurseries use labels which include a colored illustration of the plant.

Shipping labels on the outside of boxes or packages of nursery stock, in addition to the name and address of the sender and destination, should carry the messages "LIVE PLANTS," "PERISHABLE," and "KEEP FROM EXCESSIVE HEAT AND FREEZING." Large red and white labels with these messages are often applied to several sides of the package.

Figure 115. Several kinds of plant labels.

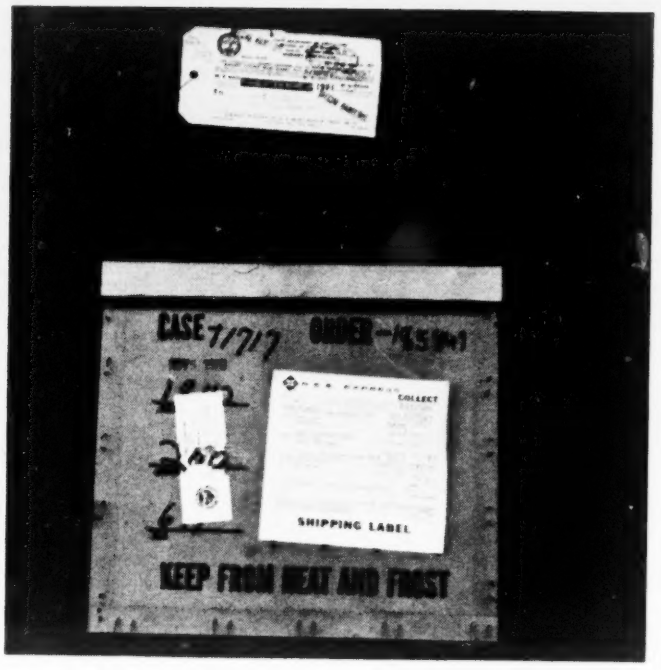

Figure 116. Shipping label and quarantine inspection certificate.

Packing and Shipping

Balled and Burlapped Stock

Wholesale nurseries attempt to book orders for B&B stock, whether deciduous or evergreen, sufficiently ahead of time so that the stock may be freshly dug only a few days before the pickup or shipping date. In instances in which many large size deciduous trees need to be dug by hand to fill an order, a week may be required to accumulate the needed stock. Allowance must be made for wet weather, which may interfere with digging and delay the operation.

Descriptions of the operations of digging B&B stock by hand and by machinery are given on pages 134 and 135.

Most wholesale nurseries maintain a small inventory of B&B stock held under lath shade and plunged in peat beds or under intermittent mist for filling small quantity orders quickly.

Some nurseries have successfully tried wintering B&B stock (dug in late fall) in polyethylene film-covered enclosures in the same way that container-grown stock is handled. This allows the nursery to have B&B stock ready for sale much earlier in the spring than is otherwise possible, because digging must be delayed in spring until the soil has thawed and

Figure 117. Lath-shaded holding area for B&B and container stock.

Figure 118. B&B stock is often handled on pallets.

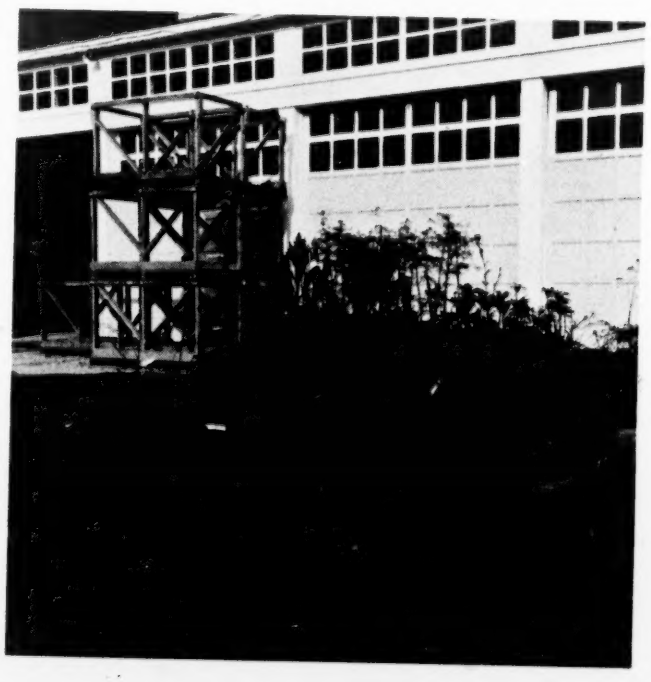

Figure 119. An individual order of container stock assembled on pallets.

Figure 120. B&B trees on a pallet being moved with a fork lift.

Figure 121. A fork lift speeds loading of B&B deciduous trees.

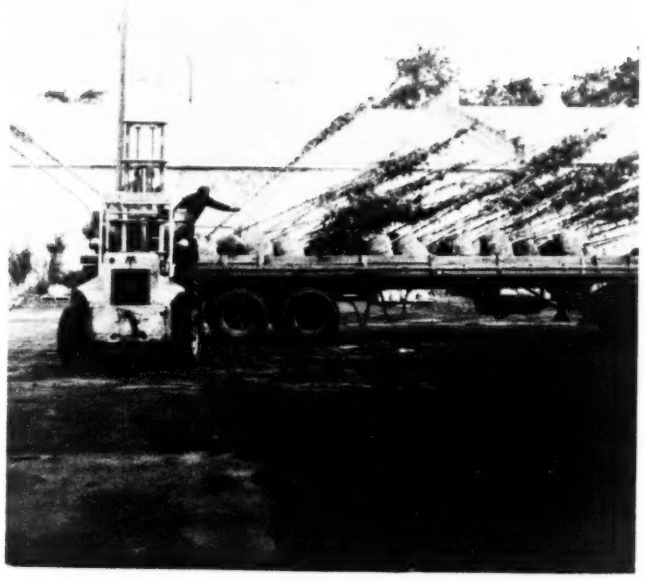

Figure 122. The trees are placed on their sides on a flat bed trailer truck.

Figure 123 . The trees are tied firmly in place with ropes to prevent movement.

Figure 124. A tarpaulin cover protects the trees from drying air blasts.

dried sufficiently so digging is possible. It seems likely that this practice of digging B&B stock and holding it over winter will be used by many more nurseries in the future.

Standard grades for B&B stock are indicated on pages 140 and 141, and they are explained in detail in Reference 48, USA Standard for Nursery Stock.

Large B&B stock may be shipped on flatbed trucks as shown in Figures 122 and 123. It must be roped firmly in place to prevent shifting of the load. It is covered with tarpaulins to prevent drying of the tops as well as the soil balls.

Medium to small size B&B stock is transported in covered trucks or in open trucks with tarpaulin covers. It must be held firmly in place to avoid breakage.

B&B stock is occasionally crated and shipped by express. They must be handled upright, with the soil balls firmly held in place with strips of wood. The tops must not be tightly enclosed; air should move freely around them. This air movement is especially important for narrowleaved and broad-leaved evergreens.

The peak shipping months for B&B material are March, April, May; September, October, November; and early December.

Cold Storage Stock

Bare-root deciduous stock is dug in the fall after the foliage has dropped from the plants. A description of how it is dug is given on page 135. It is stored in large storage buildings with the roots covered with moist shingletow. One kind and grade is stored in each clearly labeled bin or space. This gives easy access for filling orders.

Standard grades for bare-root stock are indicated on page 140, and are discussed in detail in Reference 48, USA Standard for Nursery Stock.

The storage temperature is maintained at about 35°F by adjusting the amount of outdoor air entering the building. Dirt floors are used in these buildings to aid in maintaining a high relative humidity. The plants must not be wet, however, or rot diseases may damage the stock. Circulating fans are often used in storages to prevent stratification of air tempera-

ture layers and to avoid pockets of air with excessively high relative humidity. Often certain plants that are known to be particularly susceptible to certain diseases during the storage period are sprayed with an appropriate fungicide shortly after being placed in storage. Rose plants are stored in refrigerated storage at a steady temperature just above freezing, rather than common storage, because their dormancy is easily broken by fluctuating temperatures which will cause them to sprout, sometimes long before the shipping season.

Certain bare-root plants such as roses and fruit trees that must undergo unusually long or unfavorably dry shipping conditions are often protected from drying by being coated with paraffin before packing. This is done by quickly dipping them into melted paraffin in large tanks. Slow dipping would cause heat damage to the plants.

Bare-root stock is readily shipped long distances because of its light weight. Heavy corrugated cardboard boxes are used for small quantities, while wooden shipping crates may be used for large orders. The containers are prepared by lining them with heavy water-proof paper, or with sheets of polyethylene film. The roots of each bundle of plants are wrapped in moist sphagnum moss or shingletow. Wooden or bamboo stakes may be included in the bundle to prevent breakage in the case of plants having very brittle stems. Each bundle is individually wrapped in waterproof paper, firmly tied, and labeled. The plants must be packed or otherwise held firmly in place to avoid damage that could occur if they move within the box or crate during shipping. Wooden

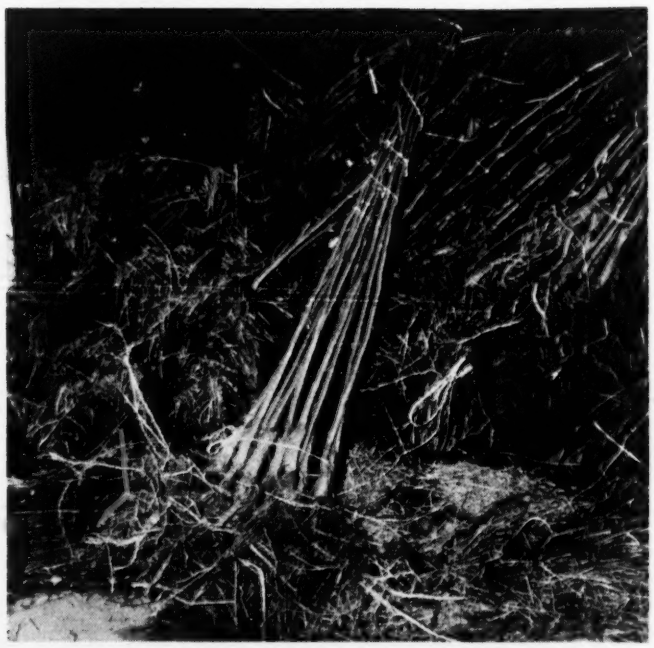

Figure 125. Bundles of bare-root "Shademaster" Honeylocust in storage. (Courtesy Conard-Pyle Co., West Grove, Penna.)

cleats are often used for this purpose if the container is not completely filled with plants.

Bare-root nursery stock produced in Northeastern States may be shipped to Southern States in late February; to the Middle South in March; to points having about the same latitude as the nursery, in early April; and to Northern States in late April. Some bare-root stock is also shipped in late October and November.

Container-Grown Stock

Container-grown nursery stock has several marketing advantages over B&B and bare-root stock. It can be sold at any season of the year because it can be moved and planted with no disturbance of the root system (in actual practice, they are not marketed in Northeastern States in mid-winter because transporting them may result in low-temperature damage to the tops, and frozen soil prevents customers from using them at that time.) Because they do not need to be dug, they can be quickly and easily moved from the growing area to the shipping area when orders are being filled.

Certain plants sometimes sold in containers were not actually grown in them. Japanese yew, for example, that is marketed in containers is actually field-grown stock that was lifted and planted in the container at marketing size. Reputable nurseries make certain that the soil ball remains intact during the potting operation so the plants will perform well. These plants, carefully potted, stand shipping better than B&B plants of the same kind. Some bare-root stock, garden roses, and some kinds of deciduous shrubs and small trees are sometimes potted in early spring and allowed to develop root and top growth before being sold in containers.

Standard grades for container stock are described in Reference 48, USA Standard for Nursery Stock.

Container stock is usually moved and loaded onto trucks by means of pallets and fork lifts as shown in Figure 120, page 180.

When large orders of container-grown stock are shipped by trailer-truck, one method of loading the plants is to stack them leaving spaces between the containers for the tops of the plants, as described on pages 143 through 147 in Reference 11, Container Growing. This must be carefully done so there is no possibility of the load shifting during the transportation. Another, perhaps safer, method to transport them would

be to use a truck with shelves spaced the height of the plants. Figure 126 illustrates this method, with 2 layers of plants. Regardless of the method used, the containers must be held firmly in place to prevent movement and damage to the plants while they are being transported.

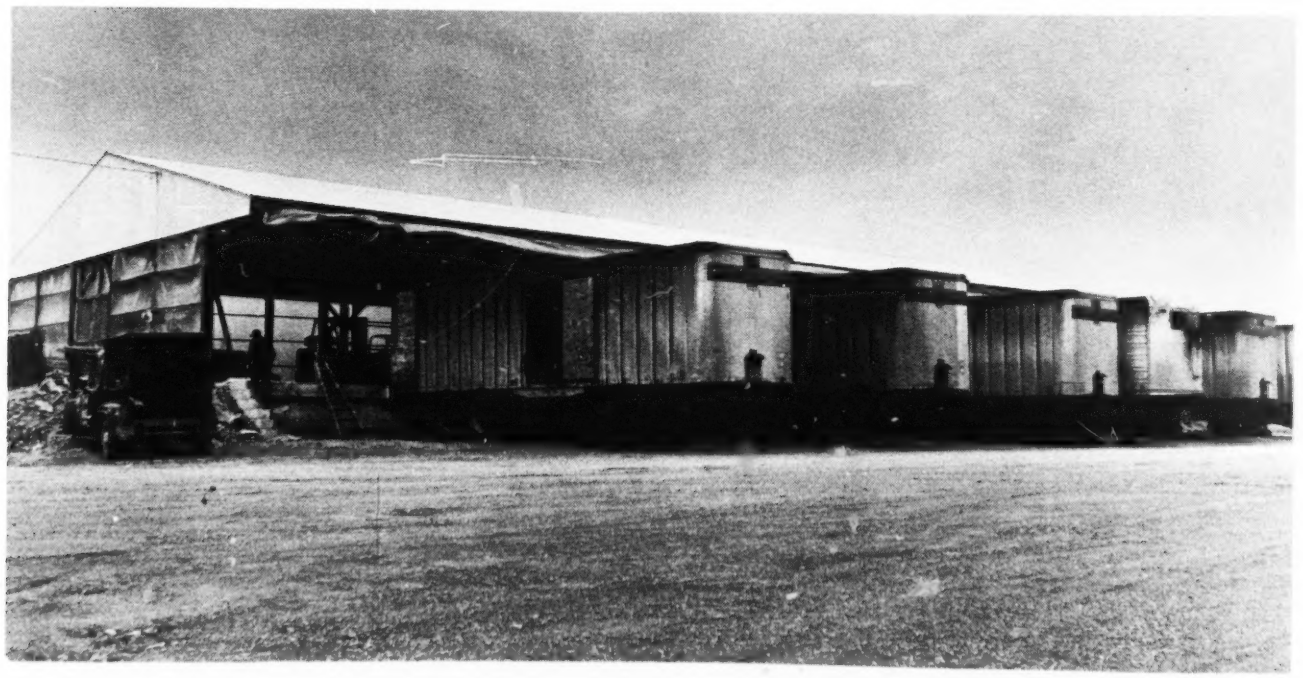

Figure 126. Container stock is often shipped on shelves in enclosed trailer trucks. (Courtesy Conard-Pyle Co., Inc., West Grove, Penna.)

Quarantine Laws

About 100 years ago, when the gypsy moth was brought into this country from Europe, it became obvious that insects or diseases brought into this country from foreign lands can cause vastly more damage in a new location than they do in their place of origin where natural enemies or climatic factors help to control them.

It was not until 1912 that the importance of this problem was sufficiently recognized so that the federal plant quarantine laws were enacted, and the enforcement of them was given to the Plant Protection Division of the Agriculture Research Service, which is under the direction of the Secretary of Agriculture.

The federal plant quarantine laws prevent the introduction of foreign plant pests into the United States. They also restrict movements of plants, equipment, or anything else likely to carry the pests from an infested (or infected) area to an area not infested (infected). These laws also provide for steps to be taken to eradicate the pests in the area of infection or infestation.

More than 10 billion dollars are lost in the United States each year in damage and costs to control certain insects, nemas and other destructive plant pests and diseases. Most of this loss is caused by alien pests and diseases which came into the country before federal quarantine laws were enacted in 1912. However, several highly destructive pests have entered this country since that time. They include the European chaffer in 1940, Japanese beetle in 1941, and the cereal leaf beetle in 1962.

State and federal plant protection officials cooperate in conducting plant pest eradication programs. The U.S. Department of Agriculture cooperates with the States in enforcing state quarantines directed against pests which are a national or regional problem. The United States, Canada, and Mexico cooperate in regulating the spread of pests by controlling the movement of regulated articles between the countries.

Areas which are considered infested by pests are called regulated areas. These may involve entire States or parts of states. The Director of the Plant Protection Division issues orders regulating the movement from the premises of articles which could spread a pest and require treatment of outgoing shipments when necessary. An area remains under regulation until the Director determines that the pest no longer. exists within it.

Regulated articles are also listed and described in the quarantines. They include commodities, equipment, and transportation facilities known to be pest carriers, or items that might spread the pest. Examples of these may be plants on which the adult insect can feed, soil in which they may live, articles on which they may lay eggs, or vehicles that might transport them.

In order to move plants or equipment covered in the regulations, nurserymen must use appropriate treatments to eliminate the danger of

spreading the pests. Fumigation of the plants and/or soil with prescribed materials is a widely used control measure. Farm and other equipment and tools are freed of pests by cleaning with water, or air or steam under pressure. Pests that live in the soil may be controlled by the application of appropriate materials to the soil. The above-ground parts of affected plants are sprayed or dusted with appropriate materials. Large nurseries have individuals who specialize in controlling plant pests and are responsible for fulfilling all quarantine regulations.

After an inspector has examined the treated articles and found them to be free of pests, he can issue a certificate or a permit which will allow the nurseryman to move the articles from the area under quarantine. By law, every individual who sends or takes plant material out of a state must have it officially inspected and attach the certifying label to the plant or the container.

Reference 1, AAN Plant Quarantine Wall Chart provides, in very convenient chart form, the fees involved and the pests under quarantine, for each state, under federal and state laws.

The continued profitable marketing of high quality nursery products depends, to a great extent, on the control of insects and diseases. Most nurserymen recognize the serious need for quarantine regulations and make every effort to cooperate fully with federal and state inspectors.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

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USA Standard for Nursery Stock, Amer. Assn. of Nurserymen, Inc., Washington, DC, 1969.

State maps of quarantine regulated plant material.

1971 Buyers Guide for Pennsylvania Nursery Stock, Dept. Agr. Commonwealth of Pennsylvania, Harrisburg, PA, 1971.

Supplies

Humidity indicator	Peat moss	Shipping twine
Plastic labels	Wax or paraffin	Shipping boxes
Plastic tags	Burlap	Shipping tags
Sphagnum moss	Waterproof paper	Quarantine inspection certificate
Dry straw	Polyethylene film	
State and federal plant quarantine maps	Shingletow	

Suggested Learning Activities

1. Have students visit a large wholesale nursery in early spring to observe how newly dug stock is handled, the physical aspects of the storage and shipping facilities, and how orders are filled from stock, assembled, labled, and packaged for shipping.

2. Invite a nurseryman to visit with the class in January or February, (when he is most likely to be available), to discuss advertising, promotion, inventory control, and pricing.
3. Distribute wholesale catalog to the class and discuss how they are organized and the information that they give to buyers of nursery stock.
4. Familiarize the class with materials used for shipping nursery stock, such as: waterproof paper, burlap, straw, sphagnum moss, peat, labels, shingletow, twine, tags, boxes, and a quarantine inspection certificate.
5. Using the AAN Plant Quarantine Wall Chart, have the class make a list of pests under quarantine and the fees for their state.
6. Invite the Plant Protection Inspector assigned to your area to talk in class about inspection and certification services and about federal and state plant quarantine laws. He should also be asked to talk on plant pests and diseases of nursery crops.

Suggested Placement Experience

If possible, arrange for interested students to assist in the work in the shipping area of a large nursery during either or both the spring and fall shipping seasons.

Test

1. In what ways do wholesale nurseries advertise?
2. Give 2 ways in which wholesale nurseries promote their products.
3. What is the advantage of having a display ground?
4. Explain long-range inventory control in a nursery.
5. How is a "running inventory" of saleable stock maintained?
6. Give the things to be considered in setting the selling price for a particular plant.
7. What are the advantages of using standard grades for nursery stock?

8. What bases are used for grading nursery stock?
9. What will happen to bare-root stock in the storage if the relative humidity is not properly maintained?
10. Name the peak months for shipping B&B stock.
11. Describe how to label and pack bare-root stock properly for express shipment.
12. What special treatment is often given to rose and fruit tree plants to prevent them from drying while being shipped long distances?
13. Briefly describe 2 ways to load container stock into a trailer truck.
14. Why are insects and diseases that have been brought into this country often more troublesome than those that naturally occur here?
15. Under what circumstances can a nursery ship plants outside of a quarantine area that includes the nursery?

CHAPTER 9

HOW MANAGERS THINK

Student Learning Objectives

1. To learn how managers make decisions.
2. To learn how managers make use of facilities, money, and personnel to produce a product profitably.
3. To learn some characteristics of good management.
4. To learn the importance of cooperation among employees.
5. To learn how responsibility is organized in a nursery.
6. To learn about trade organizations and publications.

Key Questions

1. What is the main goal of a nursery?
2. What 3 things are managed by a nurseryman?
3. What 4 thought steps are used by management in solving a problem?
4. Distinguish between long-range, middle-range, and short-range decisions.
5. What are the 3 basic needs of every person?
6. Why is the work of a nursery organized into areas of responsibility?

A large part of the job satisfaction that nursery employees have is not just earning good wages, but participation in the production of plants that are of such good quality that everyone working in the nursery is proud of them. In other words, a happy, productive, cooperative employee is one who feels that his work is worthwhile. It is one of the functions of good management to keep employees feeling this way. In order to understand how management does this, together with making production of nursery plants a profitable enterprise, let us examine how management thinks, and what it does to get cooperation among employees.

Figure 127. The functions of management are planning, executing, controlling, and evaluating.

How Managers Think

The nurseryman must constantly keep in mind that the main goal of the nursery is to produce and sell good quality plants at a profit. He does this with good management of three things: the physical plant (land, buildings, equipment, and supplies), money, (capital invested in the physical plant and cash to cover day-to-day expenses between peak sales periods), and people (workers, foremen, salesmen, managers).

The nurseryman must make sure the physical plant is capable of an efficient operation. Repairs and needed maintenance must be done promptly. Changes for greater efficiency, such as expanding buildings or buying new machinery, must be considered frequently.

The money tied up in the physical plant is often referred to as "invested capital," while the cash to cover current expenses is called "liquid capital." Nurseries may be owned by people who buy into them in anticipation that the nursery will make sufficient profit so that the dividends will be more than if they had simply put their money into a savings account. Liquid capital may be cash that the nursery keeps on hand in a bank account, or some of it may be borrowed from a bank (and must then be returned with interest). Liquid capital is used to buy hand tools and supplies and to pay wages and salaries. Money, too, must be used

wisely for a successful business. Reference 43, Sound Cash Management and Borrowing, discusses financial management in some detail.

People are the most important of the 3 things a nurseryman manages. Although the nurseryman is responsible for everything that takes place in the nursery, he cannot possibly supervise every individual in the firm. He delegates areas of responsibility to managers and others as indicated in the organization chart shown on page 29 and explained in Chapter 2. The nurseryman is constantly attempting to move people upward in the organization as they demonstrate increased productivity and ability, and willingness to assume increased responsibility (each upward movement, also means higher wages for the individual). A nurseryman needs good employees and will do everything he can to keep them.

At this point let us look at the role management plays in a nursery business and what the functions of management are.

Functions of Management

To organize his thoughts, the nurseryman uses four steps in a cycle when considering the management of the physical plant, money, and people. These steps are (a) planning, (b) executing, (c) controlling, and (d) evaluating. Evaluating is then followed by planning, and the cycle is continued. The management is continuously at one point or another in this cycle in thinking through a problem in managing the nursery.

Planning

Plans are programs for future action. Planning is necessary in that it presents a scheme for operating the firm. Plans should reflect short- and long-range objectives including what should be done, by whom, through what channels, to what effect.

Due to the fact that the future is unknown, all planning has basic elements of uncertainty. Predictability and probability play a great role.

Many of the facts that are needed must be obtained from records kept by the nursery. Examples of the forms often used may be seen in Reference 38, "Record Keeping and Data Acquisition," Section 12 of the Nursery Management Handbook.

Due to the fact that planning is the first phase of the management cycle, it should be as effective as possible. Figure 128, "The planning activity," shows courses of action often used for carrying out a basic planning process.

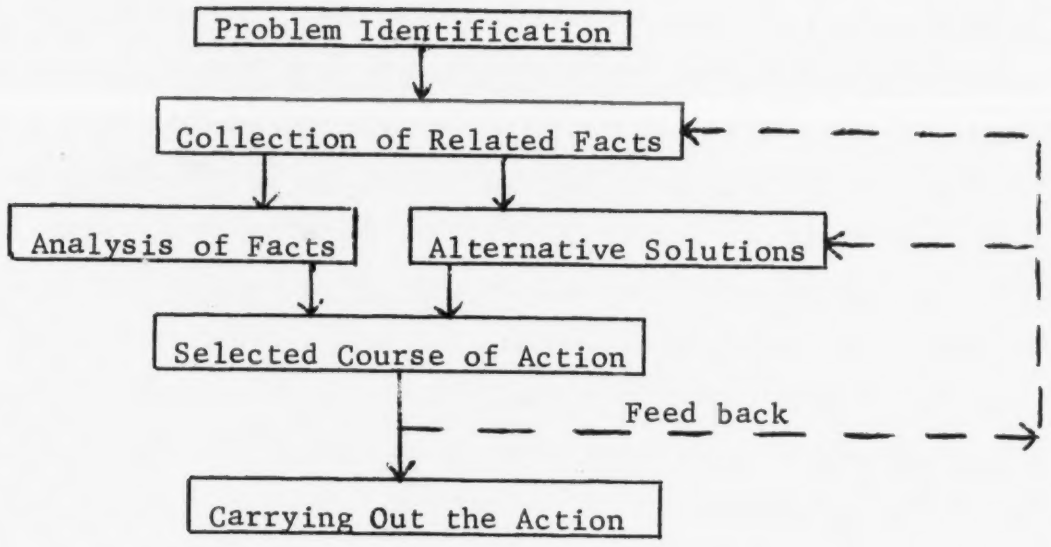

Figure 128. The planning activity.

Execution

Carrying out the plan is referred to as execution. In carrying out a change in a way of doing something, it is essential that everyone involved has a clear idea of why the change is being made and what results are expected. If a transplanting step can be eliminated by sticking cuttings into flats rather than into a bench, it is necessary that the workers and foreman understand the reasons for the change. Their willing cooperation in making the change is important.

Controlling

The controlling process is another important element of effective management. The basic aim of controlling is to assure that results of the change conform as closely as possible to the original goals. Three main parts should always be present in the controlling process. They are:

1. Guidelines for desired outcome - making sure that everyone involved understand the desired results.

2. Comparison of results with standards that were set - everyone involved should be informed whether or not the standards or goals were achieved.

3. Corrective action -- whenever current activities are not producing desired results, corrective measures should be taken immediately by everyone involved.

These 3 parts of controlling; guidelines, comparison, and correction,

are essential parts of the controlling process.

Evaluation

The last of the 4 management functions (planning, executing, controlling, and evaluating) is evaluation. The main purpose of evaluation is to determine whether any further improvements can be made in the change that was undertaken. For example, it might be found that handling deciduous cuttings in flats actually results in greater productivity, and the possibility of adopting this technique for narrowleaved evergreens may be considered next.

Decision Making

Employees often wonder how the nurseryman and managers spend their time. Acutally, they spend a high percentage of it making decisions about what courses to follow in the conduct of the business.

The kinds of problems they work on could be classed into long-range middle-range, and short-range ones.

Long-Range Problems

Some long-range questions which could be considered by meetings involving the owners, the nurseryman, and managers are:

Would it be advantageous to move the nursery to a new location?

Should the nursery expand its production of container stock?

Should the nursery produce a new product line - say turfgrass, for example?

Should the nursery open one or more garden centers to retail part of its production?

Should the nursery consider expanding its marketing area? If so, what areas should be added?

Should the nursery consider merging with another one to make production and marketing more economical?

Middle-Range Problems

Some middle-range questions that could be considered by meetings of the nurserymen and the managers are:

What changes in prices should be made in the next catalog?

Are there any new pieces of equipment that could speed operations?

What new cultivars should be added to the items already being grown?

How many workers will be needed for the next year's operation?

What supplies will be required for the next year's operation?

Short-Range Problems

Short-range problems are usually solved by managers and/or foremen, often in consultation with one another. Some examples are:

Planning the work for the week.

Are there any persons who should be recommended for salary increases and more responsible positions?

Are there workers who need extra instruction or additional help?

Instructing new workers in skills.

Maintaining and repairing equipment.

Making sure that plants are dug at the right time for storing or filling orders.

Making up and carrying out a propagation schedule.

Making up and carrying out a shipping schedule.

Devising and following a pest control program.

Cooperation Among Employees

An efficient, smoothly operating nursery is one in which each employee sees himself as part of a team working toward the goal of producing good quality plants at a profit. Efficient, smooth operation is dependant not only on good management, but also upon people who work well together. Working well together is influenced mostly by people's attitudes toward work and toward one another.

The Employee as a Person

Everyone, whether he recognizes it or not, has 3 basic needs in life. Recognizing these needs, and directing his efforts toward meeting them leads toward happy relations with coworkers and everyone he contacts, as well as efficient productivity and job satisfaction. The 3 needs are physical needs, social needs, and psychological needs.

The physical needs are for food, clothing, and a place to live. The main reason why the average person works is to fill those needs for himself

and his family. Persons who do not think that they have responsibility to fill these needs are seldom productive employees.

The social need is the need for feeling one is accepted by others and the feeling that he belongs to a group. In a nursery this might be referred to as "teamwork." If you feel that you and the people with whom you work are working together toward a common goal, your group will be productive. Some people (regardless of age) have not matured to the point where they work well with others. This inability to get along with others is a more frequent cause for dismissal than inability to perform the work. Good management cannot tolerate time wasted by personal arguments of employees. You may have wondered why your instructor sometimes makes group assignments--he is attempting to help you to develop teamwork as well as knowledge and skill.

Each individual also has psychological needs such as self confidence and prestige. Self confidence comes to a person who has worked hard enough at learning certain skills so that he knows without doubt that he can do them well. If he does them well he is productive. Prestige could be defined as a feeling that his job is important and that his work is worthwhile. The prestige of added responsibility and increased wages come to those who have shown that they can be productive and responsible.

The Employee on the Job

A new nursery employee should make certain when he accepts the job that he knows to whom he is responsible. Sometimes this is not clearly stated in a job interview. If he will have people working under his supervision, he should have a clear understanding of their responsibilities to him.

The new employee should also ask what kinds of tasks he will be expected to do.

Sometimes a new employee does not clearly understand how much he will be paid or how frequently. He should also inquire about employee benefits (such as hospitalization, insurance, etc.). It would also be a good idea to ask the requirements for wage increases and promotion.

New employees find that several weeks are required to get to "know the ropes" and to develop high productivity and teamwork with fellow employees.

Most managers have acquired their positions through experience and

know that experience involves making good use of mistakes. They are not likely to be too harsh the first time a particular mistake is made! Managers and foremen also help workers who need extra instruction or help in understanding the work they do. Managers sometimes invite people to move to a different position as they discover abilities and talents that can be most useful in a different area of work.

One person can do only one thing at a time. Most of us can do a certain amount of thinking and physical activity that are not directly related, but the number of persons who can really do several completely independent things at the same time are very rare! Within a nursery, the work is organized in such a way that each person makes a particular, and usually different, contribution to the total number of tasks to be done. One man digs plants while another tags them, another sows seeds, while another may be taking an order from a customer. Each has a limited number of tasks to do and a clearly defined area of responsibility.

In order to coordinate the work and responsibilities a nursery is organized in such a way that groups of people are responsible to individuals who in turn are responsible to others who are responsible to the nurseryman. Thus, a nursery worker is responsible to a foreman, who is responsible to a manager, who is responsible to the nurseryman. Several examples of charts showing the organization of responsibility in nurseries are given on pages 29 and 30 in Chapter 2. "Occupations in Nursery Production."

You may wish to read more about cooperation among employees in "Unit X. People Make or Break the Business," page 137 in Reference 7, Business Leadership in the Agricultural Industry.

Trade Associations and Trade Publications

Trade associations and trade publications provide ways in which nurserymen exchange ideas and solve mutual problems.

The American Association of Nurserymen, 835 Southern Building, Washington, D.C. 20005 serves nurserymen in the entire nation.

Some regional associations of nurserymen include:

Eastern Regional Nurserymen's Association

New England Nurseryman's Association

Del - Mar - Va Association of Nurserymen

Some associations related to the nursery industry are:

Horticultural Research Institute

International Plant Propagators Society

International Shade Tree Conference

Mail Order Association of Nurserymen

National Arborist's Association

National Landscape Nurserymen's Association

Wholesale Nursery Growers of America, Inc.

Forty-four states also have state associations of nurserymen.

The addresses of the secretaries of these associations change frequently. The American Association of Nurserymen keeps a current record of them at all times and will provide addresses upon request.

Some trade publications of interest to nurserymen are:

American Nurseryman
343 South Dearborn Street
Chicago, IL 60604

Nursery Business
910 Elm Grove Road
Elm Grove, WI 53122

Pacific Coast Nurseryman and Garden Supply Dealer
832 South Baldwin Avenue
Arcadia, CA 91007

Southern Florist And Nurseryman
P. O. Box 1868
120 St. Louis Avenue
Forth Worth, TX 76101

Trees Magazine
7621 Lewis Road
Olmstead Falls, OH 44138

Weeds, Trees and Turf
9800 Detroit Avenue
Cleveland, OH 44102

A more detailed description of most of these publications may be found in Reference 51, Your Future in the Nursery Business, pages 141-144.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

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Audio-Visual Aids

Human Relations in Agriculture, film strip, Ohio State Univ., Agdex 903/017, Columbus, OH.

Suggested Learning Activities

1. Invite a nurseryman to discuss with the class the kinds of decisions nursery managers have to make.
2. Invite a nurseryman to discuss the importance of cooperation among employees in a nursery.
3. Have students prepare a sample budget for a one year's operation of the school nursery.
4. Have students set up an organizational chart for managing the school nursery. If feasible, put it into actual operation, with advanced students occupying the more responsible positions. A periodic evaluation should be made.
5. Advanced students may want to study further about management in References 26 and 43.

Suggested Placement Experience

Once every two weeks have a group discussion about personal relations with students already in placement training. If possible, select several students to discuss this subject as a panel before a sophomore or junior class in ornamental horticulture.

Test

1. What is the main goal of a nursery?
2. Name the 3 things a nurseryman manages?
3. Which is the most important of the 3 things the nurseryman manages?
4. Name the 4 thought steps used by a nurseryman in managing a particular problem.
5. Give an example of a long-range nursery management decision.
6. Give an example of a middle-range nursery management decision.
7. Give an example of a short-range nursery management decision.
8. Why is it important that an employee feel that his work is worthwhile?
9. What is meant by making good use of mistakes?
10. What does an organization chart tell us about areas of responsibility?

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APPENDIX A

Recommended Trees, Shrubs, And Flowers For School Arboretums

STANDARD DECIDUOUS TREES

	Common Name	Technical Name	Hardiness Zones
	Red Maple	Acer rubrum	3-8
	Column Red Maple	Acer rubrum columnar	3-8
	Norway Maple	Acer platanoides	3-8
	Norway Maple	Acer platanoides 'Crimson King'	3-8
(f)	Sugar Maple	Acer saccharum	3-8
	Pyramid Sugar Maple	Acer saccharum pyramidale	3-8
(f)	European Beech	Fagus sylvatica	4-8
	Purple Beech	Fagus sylvatica atropunicea	4-8
(f)	Ginkgo	Ginkgo biloba	4-8
	Sentry Ginkgo	Ginkgo biloba fastigiata	4-8
	Thornless Honeylocust	Gleditsia triacanthos inermis	4-8
	Moraine Locust	Gleditsia triacanthos inermis Moraine	4-8
(f)	Sunburst Honeylocust	Gleditsia triacanthos inermis Sunburst	4-8
(f)	Sweet Gum	Liquidambar styraciflua	4-8
	Tulip Tree	Liriodendron tulipifera	4-8
	Black Tupelo	Nyssa sylvatica	4-8
	Northern Red Oak	Quercus borealis	4-8
	Scarlet Oak	Quercus coccinea	4-8
	Shingle Oak	Quercus imbricaria	5-8
(f)	Pin Oak	Quercus palustris	4-8
	English Oak	Quercus robur	5-8
	Pyramidal English Oak	Quercus robur fastigiata	5-8
	Live Oak	Quercus virginiana	7-8
(f)	Thurlow Weeping Willow	Salix elegantissima Thurlow	4-8
	Little-Leaf Linden	Tilia cordata	3-8

(c) recommended for container stock for school nursery

(f) recommended for field stock for school nursery

SMALL DECIDUOUS TREES

	Common Name	Technical Name	Hardiness Zones
	Amur Maple	Acer ginnala	2-8
	Japanese Maple	Acer palmatum	5-8
(c) (f)	Bloodleaf Japanese Maple	Acer palmatum atropupureum	5-8
	Silk Tree	Albizzia julibrissima rosea	6-7
	Serviceberry	Amelanchier canadensis (laevis)	4-8
	European White Birch	Betula pendula	2-7
	European Hornbeam	Carpinus betulus	5-8
	Pyramidal European Hornbeam	Carpinus betulus fastigiata	5-8
(f)	Eastern Redbud	Cercis canadensis	4-8
(f)	Flowering Dogwood	Cornus florida	4-8
	Kousa Dogwood	Cornus kousa	5-8
	Cornelian Cherry Dogwood	Cornus mas	4-8
	Paul's Scarlet Hawthorn	Crataegus oxycantha Pauli	4-7
	Washington Hawthorn	Crataegus phaenopyrum	4-7
	Russian Olive	Elaeagnus angustifolia	2-8
	Franklinia	Franklinia alatamaha	6-8
	Gold-Rain Tree	Koelreuteria paniculata	5-8
	Laburum	Laburnum vossi	5-8
	Kobus Magnolia	Magnolia kobus	4-8
(f)	Saucer Magnolia	Magnolia soulangeana	5-8
	Star Magnolia	Magnolia stellata	5-8
	Sweetbay Magnolia	Magnolia virginiana	5-8
	Arnold Crabapple	Malus arnoldiana	4-8
	Carmine Crabapple	Malus atrosanguinea	4-8
	Dorothea Crabapple	Malus dorothea	4-8
	Japanese Flowering Crabapple	Malus floribunda	4-8
	Hall's Parkman Crabapple	Malus halliana 'Parkman'	5-8
	Hopa Crabapple	Malus hopa	4-8
	Bechtel Crabapple	Malus ioensis 'Plena'	2-8
	Eley Purple Crabapple	Malus purpurea 'Eleyi'	4-8
(f)	Sargent Crabapple	Malus sargenti	5-8
	Scheidecker Crabapple	Malus scheideckeri	4-8

SMALL DECIDUOUS TREES (Continued)

	Common Name	Technical Name	Hardiness Zones
	Pink Cloud Pissard Plum	Prunus cerasifera 'Rosea'	3-7
(f)	Kwazan Cherry	Prunus serrulata	5-7
	Higan Cherry	Prunus subhirtella	5-7
	Weeping Higan Cherry	Prunus subhirtella pendula	5-7
	Yoshina Cherry	Prunus yedoensis	5-7
	European Mountain Ash	Sorbus aucuparia	2-8

EVERGREEN TREES

	Common Name	Technical Name	Hardiness Zones
(f)	White Fir	Abies concolor	4-8
	Cedar of Lebanon	Cedrus libani	7-8
(c)	Sawara Falsecypress	Chamaecyparis pisifera	3-8
	Cryptomeria	Cryptomeria japonica	5-8
(c)	American Holly	Ilex opaca	5-8
(c)	Red Cedar	Juniperus virginiana	2-8
(c)	Southern Magnolia	Magnolia grandiflora	7-8
(c)	Norway Spruce	Picea abies	2-8
	Servian Spruce	Picea omorika	4-8
(c) (f)	Koster Blue Spruce	Picea pungens argentea	2-8
	Austrian Pine	Pinus nigra	4-8
	Red Pine	Pinus resinosa	2-8
(f)	White Pine	Pinus strobus	3-8
(f)	Scotch Pine	Pinus sylvestris	2-8
	Yew Podocarpus	Podocarpus macrophyllus	7-8
	Douglas Fir	Pseudotsuga menziesii	4-8
(c) (f)	Canada Hemlock	Tsuga canadensis	3-8

LARGE DECIDUOUS SHRUBS

	Common Name	Technical Name	Hardiness Zones
	Cornelian Cherry Dogwood	Cornus mas	4-8
(f)	Smoke Bush	Cotinus coggyria 'Purpureus'	5-8

LARGE DECIDUOUS SHRUBS (Continued)

	Common Name	Technical Name	Hardiness Zones
	Aldenham Spindle Tree	Euonymus europeaus 'Aldenhamensis'	3-8
	Chinese Witch-hazel	Hamamelis mollis	5-8
(f)	Shrub Althea	Hibiscus syriacus	5-8
(f)	Beauty-bush	Kolkwitzia amabilis	4-8
(f)	Amur Privet	Ligustrum amurense	3-8
	European Privet	Ligustrum vulgare	4-8
	Amur Honeysuckle	Lonicera maacki	2-8
	Tatarian Honeysuckle	Lonicera tatarica	3-8
	Sweetbay Magnolia	Magnolia virginiana	5-8
	Chinese Lilac	Syringa chinensis	5-8
	Highbush Blueberry	Vaccinium corymbosum	3-8
	Burkwood Viburnum	Viburnum burkwoodi	5-8
	Wayfaring Tree Viburnum	Viburnum lantana	3-8
	Nannyberry Viburnum	Viburnum lentago	2-8
	Blackhaw Viburnum	Viburnum prunifolium	3-8
	Sargent Cranberrybush Viburnum	Viburnum sargenti	4-8
	Tea Viburnum	Viburnum setigerum	5-8
(f)	Siebold Viburnum	Viburnum sieboldi	4-8
	American Cranberrybush Viburnum	Viburnum trilobum	2-8

NARROWLEAF EVERGREEN SHRUBS

		Common Name	Technical Name	Hardiness Zones
	(c)	Slender Hinoki Falsecypress	Chamaecyparis obtusa gracilis	3-8
(c)	(f)	Pfitzer Juniper	Juniperus chinensis pfitzeriana	4-8
		Sargent Juniper	Juniperus chinensis 'Sargenti'	4-8
	(c)	Creeping Juniper	Juniperus horizontalis	5-8
(c)	(f)	Andorra Juniper	Juniperus horizontalis plumosa	3-8
(c)	(f)	Mugho Pine	Pinus mugo mughus	4-8
	(c)	Spreading English Yew	Taxus baccata 'repandens'	6-8
(c)	(f)	Spreading Japanese Yew	Taxus cuspidata	4-8
	(c)	Upright Japanese Yew	Taxus cuspidata capitata	4-8
	(c)	Dwarf Japanese Yew	Taxus cuspidata nana	4-8

NARROWLEAF EVERGREEN SHRUBS (Continued)

	Common Name	Technical Name	Hardiness Zones
(c)	Hatfield Yew	Taxus media 'Hatfieldi'	4-8
(c) (f)	Hick's Yew	Taxus media 'Hicksi'	4-8
(c) (f)	Ware's Arborvitae	Thuja occidentalis 'Wareana'	2-8

LARGE, BROADLEAF EVERGREEN SHRUBS

	Common Name	Technical Name	Hardiness Zones
(c)	Japanese Aucuba	Aucuba japonica	7-8
(c)	Common Box	Buxus sempervirens	5-8
(c)	Common Camellia	Camellia japonica	7-8
	Sasangua Cammelia	Camellia sasangua	7-8
(c)	Evergreen Euonymus	Euonymus japonica	8
(c)	American Holly	Ilex opaca	5-8
(c)	Chinese Photinia	Photinia serrulata	7-8
	Cherry Laurel	Prunus laurocerasus 'Schipkaensis'	6-7
(c)	Rose Bay Rhododendron	Rhododendron maximum	3-8
	Leatherleaf Viburnum	Viburnum rhytidophyllum	5-8

MEDIUM DECIDUOUS SHRUBS

	Common Name	Technical Name	Hardiness Zones
	Acanthopanax	Acanthopanax sieboldianus	4-8
(c)	Mentor Barberry	Berberis mentorensis	5-8
(c)	Japanese Barberry	Berberis thunbergi	5-8
	Flowering Quince	Chaenomeles lagenaria	4-8
(c)	Red Osier Dogwood	Cornus stolonifera	2-8
(c)	Spreading Cotoneaster	Cotoneaster divaricata	5-8
	Hedge Cotoneaster	Cotoneaster lucida	4-8
(f)	Snowflake Deutzia	Deutzia scabra candidissima	5-8
(c) (f)	Winged Euonymus	Euonymus alatus	3-8
(c) (f)	Forsythia, "Lynwood Gold," "Spring Glory," Beatrix Farrand"	Forsythia intermedia spectabilis	5-8
	Vernal Witchhazel	Hamamelis vernalis	4-8
	French Hydrangea	Hydrangea macrophylla hortensia	6-8

MEDIUM DECIDUOUS SHRUBS (Continued)

	Common Name	Technical Name	Hardiness Zones
	Winterberry Holly	Ilex verticillata	3-8
	Winter Jasmine	Jasminum nudiflorum	5-8
(f)	Kerria	Kerria japanica pleniflora	4-8
(c)	Beauty-bush	Kolkwitzia amabilis	4-8
	Regel Privet	Ligustrum obtusufolium regelianum	3-8
(c)	Winter Honeysuckle	Lonicera fragrantissima	5-8
	Blueleaf Honeysuckle	Lonicera korolkowi	5-8
(c)	Northern Bayberry	Myrica pensylvanica	2-8
	Avalanche Mockorange	Philadelphus lemoine 'Avalanche'	5-8
	Albatre Mockorange	Philadelphus virginalis 'Albatre'	5-8
	Virginal Mockorange	Philadelphus virginalis 'Virginal'	5-8
(c)	Flame Azalea	Rhododendron calendulaceum	5-8
	Korean Rhododendron	Rhododendron mucronulatum	4-8
	Royal Azalea	Rhododendron schlippenbachi	4-8
	Jetbead	Rhodotypos scandens	5-8
	Father Hugo Rose	Rosa hugonis	5-8
	Rugosa Rose	Rosa rugosa	2-8
(f)	Bridalwreath Spirea	Spirea prunifolia plena	4-8
	Van Houtte Spirea	Spirea vanhouttei	4-8
	Snowberry	Symphoricarpos albus laevigatus	3-8
(f)	Persian Lilac	Syringa persica	5-8
(f)	Fragrant Viburnum	Viburnum carlesi	4-8
(f)	Linden Viburnum	Viburnum dilatatum	5-8
	Japanese Snowball	Viburnum plicatum	4-8

MEDIUM, BROADLEAF EVERGREEN SHRUBS

	Common Name	Technical Name	Hardiness Zones
(c)	Japanese Aucuba	Aucuba japonica	7-8
(c)	Wintergreen Barberry	Berberis julianae	5-8
	Thorny Eleagnus	Eleagnus pungens	7-8
(c)	Evergreen Euonymus	Euonymus japonica	8
(c)	Spreading Euonymus	Euonymus kiautschovicus	6-8

MEDIUM, BROADLEAF EVERGREEN SHRUBS (Continued)

	Common Name	Technical Name	Hardiness Zones
(c)	Convex-Leaf Japanese Holly	Ilex crenata convexa	6-8
(c)	Burford Chinese Holly	Ilex cornuta 'Burfordi'	7-8
	Mountain Laurel	Kalmia latifolia	5-8
	Japanese Privet	Ligustrum japonicum	7-8
	Nandina	Nandina domesticum	7-8
	Japanese Pieris	Pieris japonica	6-8
	Cherry Laurel	Prunus laurocerasus 'Schipkaensis'	5-7
(c)	Laland Firethorn	Pyracantha coccinea lalandi	6-8
	Leatherleaf Viburnum	Viburnum rhytidophyllum	5-8

SMALL DECIDUOUS SHRUBS

	Common Name	Technical Name	Hardiness Zones
	Purple Box Barberry	Berberis thunbergi minor	5-8
	Japanese Quince	Chaenomeles japanica	4-8
(c) (f)	Rockspray Cotoneaster	Cotoneaster horizontalis	4-8
	Slender Deutzia	Deutzia gracilis	4-8
(c) (f)	Dwarf Winged Euonymus	Euonymus alatus compactus	3-8
	Oak-leaved Hydrangea	Hydrangea quercifolia	5-8
	Shrubby St. Johnsworth	Hypericum prolificum	4-8
(c)	Tree Peony	Paeonia suffruticosa	5-8
	Bush Cinquefoil	Potentilla fruticosa	2-8
(f)	Dwarf Flowering Almond	Prunus glandulosa	4-8
(c)	Mollis Azalea	Rhododendron kosterianum	5
(f)	Arctic Willow	Salix purpurea nana	2-8
(c)	Anthony Waterer Spirea	Spirea bumalda 'Anthony Waterer'	5-8
(c)	Dwarf European Cranberrybush	Viburnum opulus nanum	3-8
(c) (f)	Weigela	Weigela 'Bristol Ruby'	4-8

SMALL, BROADLEAF EVERGREEN SHRUBS

	Common Name	Technical Name	Hardiness Zones
(c)	Glossy Abelia	Abelia grandiflora	5-8
	Wintergreen Barberry	Berberis julianae	5-8

SMALL, BROADLEAF EVERGREEN SHRUBS (Continued)

	Common Name	Technical Name	Hardiness Zones
	Three Spine Barberry	Berberis triacanthophora	5-8
	Warty Barberry	Berberis verruculosa	5-8
(c)	Korean Littleleaf Box	Buxus microphylla 'Koreana'	5-8
	Warminster Broom	Cytisus praecox	5-8
(c)	Rose Daphne	Daphne cneorum	4-8
(c)	Somerset Daphne	Daphne somerset	5-8
(c)	Bigleaf Wintercreeper Euonymus	Euonymus fortunei vegetus	5-8
(c)	Evergreen Candytuft	Iberis sempervirens	5-8
(c)	Convex-Leaf Japanese Holly	Ilex crenata convexa	6-8
(c)	Drooping Leucothoe	Leucothoe catesbaei	4-8
(c)	Box Honeysuckle	Lonicera nitida	7-8
(c)	Oregon Holly Grape	Mahonia aquifolium	5-8
	Mountain Pieris	Pieris floribunda	4-8
(c)	Carolina Rhododendron	Rhododendron carolinianum	5-8
(c)	Catawba Rhododendron	Rhododendron catawbiense	4-8
(c)	Hybrid Azalea	Rhododendron hybrid	5-8
(c)	Hybrid Rhododendron	Rhododendron hybrid	4-8
(c)	Snow Azalea	Rhododendron mucronatum	6-8
(c)	Amoena Azalea	Rhododendron obtusa amoena	6-8
(c)	Torch Azalea	Rhododendron obtusa kaempferi	6-8
(c)	Korean Yodogawa Azalea	Rhododendron yedoensis poukhanensis	5-8
	Fragrant Sarcococca	Sarcococca ruscifolia 'Hookeriana Humilis'	7-8
(c)	Reeves Skimmia	Skimmia reevesiana	7-8

DECIDUOUS AND EVERGREEN VINES

		Common Name	Technical Name	Hardiness Zones
	(c)	Five-leaf Akebia	Akebia quinata	(D) 4-8
		Poreclain Ampelopsis	Ampelopsis brevipedunculata	(D) 4-8
		Cross Vine	Begonia capreolata	(E) 6-8
		Trumpet Creeper	Campsis tagliabuana 'Madame Galen'	(D) 4-8
(c)	(f)	European Bittersweet	Celastrus orbiculatus	(D) 2-8
(c)	(f)	Clematis	Clematis hybrids	(D) 5-8

DECIDUOUS AND EVERGREEN VINES (Continued)

		Common Name	Technical Name	Hardiness Zones
		Sweet Autumn Clematis	Clematis paniculata	(D) 5-8
	(c)	Bigleaf Wintercreeper Euonymus	Euonymus fortunei vegetus	(E) 5-8
	(c)	Algerian Ivy	Hedera canariensis	(E) 7-8
(c)	(f)	English Ivy	Hedera helix 'Baltica'	(E) 5-8
	(c)	Climbing Hydrangea	Hydrangea petiolaris	(D) 4
		Common White Jasmine	Jasminum officinale	(D) 7-8
		Henry Honeysuckle	Lonicera henryi	(D) 4-8
		Trumpet Honeysuckle	Lonicera sympervirens	(E) 3-8
		Low's Japanese Creeper	Parthenocissus tricuspidata 'Lowi'	(D) 4-8
		Veitch Japanese Creeper	Parthenocissus tricuspidata 'Veitchi'	(D) 4-8
		Passion Flower	Passiflora caerulea	(D) 8
(c)	(f)	Japanese Wisteria	Wisteria floribunda	(D) 4-8
	(c)	Chinese Wisteria	Wisteria sinensis	(D) 5

DECIDUOUS AND EVERGREEN GROUNDCOVERS

		Common Name	Technical Name	Hardiness Zones
		Goutweed	Aegopodium podograria variegatum	(D) 3-8
	(c)	Carpet Bugle	Ajuga reptans	(D) 4-8
		Sweet Woodruff	Asperula odorata	(D) 4-8
		Scotch Heather	Calluna vulgaris	(E) 4-8
		Lily-of-the-Valley	Convallaria majalis	(D) 2-8
	(c)	Creeping Cotoneaster	Cotoneaster adpressa	(D) 4-8
	(c)	Bearberry Cotoneaster	Cotoneaster dammeri	(D) 4-8
	(c)	Rockspray Cotoneaster	Cotoneaster horizontalis	(D) 4-8
	(c)	Baltic English Ivy	Hedera helix 'Baltica'	(E) 5-8
(c)	(f)	Creeping Juniper	Juniperus horizontalis	(E) 2-8
	(c)	Sargent Juniper	Juniperus chinensis 'Sargenti'	(E) 4-8
		Henry Honeysuckle	Lonicera henryi	(D) 4-8
		Canby Pachistema	Pachistima canbyi	(E) 5-8
(c)	(f)	Japanese Spurge	Pachysandra terminalis	(E) 4-8
		Chilean Pernettya	Pernettya mucronata	(E) 7-8

DECIDUOUS AND EVERGREEN GROUNDCOVERS (Continued)

	Common Name	Technical Name	Hardiness Zones
	Memorial Rose	Rosa wichuriana	(D) 5-8
	Lowbush Blueberry	Vaccinium augustifolium laevifolium	(D) 2-8
(f)	Myrtle, Periwinkle	Vinca Minor	(E) 4-8

GARDEN FLOWERS, HERBACEOUS PERENNIALS

	Common Name	Technical Name
	Japanese Windflower	Anemone vitifolia
(c)	Butterfly Weed	Asclepias tuberosa
(c)	Astilbe	Astilbe hybrids
	Shasta Daisy	Chrysanthemum maximum
(c)	Garden Chrysanthemum	Chrysanthemum morifolium
(c)	Delphinium	Delphinium hybrid (esp. D. belladonna h.)
(c)	Bleeding Heart	Dicentra spectabilis
	Gas Plant	Dictamnus fraxinella
	Globethistle	Echinops ritro (esp. 'Taplow Blue')
(c)	Daylily	Hemerocallis hybrids
	Coral Bells	Heuchera sanguinea
	Rose Mallow	Hibiscus moscheutos
(c)	Evergreen Candytuft	Iberis sempervirens
	Red Hot Poker	Kniphofia foliosa
(c)	True Lavender	Lavendula vera (esp. 'Munstead')
	Cardinal Flower	Lobelia cardinalis
	Loose Strife	Lythrum superbum
(c)	Peony	Paeonia hybrids
(c)	Oriental Poppy	Papaver orientale
	Garden Phlox	Phlox panniculata
	Globe Flower	Trollius europeus

GARDEN FLOWERS, HERBACEOUS ANNUALS

Common Name	Technical Name
Snapdragon	Antirrhinum majus
Coleus	Coleus blumei
Impatiens	Impatiens sultani
Geranium	Pelargonium hortorum
Petunia	Petunia hybrid
Salvia	Salvia splendens
Marigold	Tagetes erecta

GARDEN FLOWERS, BULBS

Common Name	Technical Name
"Autumn Crocus"	Colchicum autumnale
Crocus	Crocus species
Madonna Lily	Lilium candidum
Rubrum Lily	Lilium speciosum 'Rubrum'
Armenian Grape Hyacinth	Muscari armeniacum
Daffodil	Narcissus pseudo-narcissus
Siberina Squill	Scilla siberica
Tulip	Tulipa hybrid

APPENDIX B

Operation of Tractors and Farm Machinery

The Federal Child Labor Order listing 16 hazardous occupations in which youth under 16 years of age are not allowed to work has been amended to permit teachers of vocational agriculture to certify 14 and 15 year olds to operate farm tractors and machinery. The Hazardous Occupations Order for Farm Youth is published in the Federal Register, Volume 32, Number 216, Tuesday, November 7, 1967. Of the 16 hazardous jobs listed, only numbers 5,6,7,8,9, and 10 are exempted with certification. Employment in numbers 1,2,3,4,11,12,13,14, 15, and 16 is not permitted.

There shall be no less than 15 hours instruction in safe tractor operation with an additional 10 hours instruction in safe farm machinery operation. The training program is outlined in Special Paper No. 8, April 1969, prepared at Michigan State University for the U.S. Office of Education. Copies have been distributed to all vocational agriculture teachers through the area advisers. This publication is named in the Order and must be followed. Some units are required. A choice can be made from the remainder to complete the hours required.

It is suggested that instruction following the pattern of this program be made a part of every vocational agriculture program in the state for the benefit of all vocational agriculture students, even if there is no need for certification.

The program aims to qualify and certify 14 and 15 year olds for employment as safe operators of farm tractors and machinery. A youth below the age of 16 working on a farm owned or operated by a parent or guardian does not need a certificate. Only those employed by someone other than a parent or guardian must have completed at least 25 hours of training and hold a certificate.

Instruction must conform with the outline of Special Paper No. 8, April 1969. Basic and supplemental references are named in it. The teacher may want to use a textbook. The series of four 4-H manuals can be used. Iowa State University offers a text, "Operating Farm Tractors and Machinery," March 1969, PM450. The cost is $1.00 each. A teacher's guide is $.25. A Kansas book has been used in Pennsylvania and may still be available in some counties. Teachers may want to develop and duplicate their own materials.

The local school district decides whether to establish a certification training program in its district. A survey should be made to determine the need. Keep in mind that certificates are needed only by 14 and 15 year olds who are employed or anticipate employment on other than their home farm.

Classes may be arranged to suit any situation. They can be built into the regular vocational agriculture schedule, but it is likely that most of the students in this age bracket and in need of certificates will be eighth or ninth graders. Another complication is the possibility that others in need of the training are not vocational agriculture students. Situations like this may necessitate the use of activity periods, periods in which the agriculture teacher can be relieved, or even out-of-school time. This is entirely a local option.

APPENDIX C

Calendar of Nursery Operations

January

Take hardwood cuttings of certain deciduous and evergreen plants.
Inventory supplies and order needed items.
Maintain and repair equipment.
Sow seeds of azalea and rhododendron in the greenhouse.
Graft cultivars of coniferous evergreens.

February

Root graft fruit trees and crabapples.
Maintain and repair equipment.
Prune trees.
Ship orders for Southern States.

March

Dig B&B stock.
Prepare open fields for planting.
Plant lining out stock.
Plant container stock.
Sow seeds in outdoor seedbeds.
Stick callused hardwood cuttings in the field, beds, or containers.
Plant callused deciduous grafts in the field, beds, or containers.
Plant potted evergreen grafts in the field.
Take soil samples and have them analyzed.
Ship orders for Middle Atlantic States.

April

Dig B&B stock.
Apply selective herbicides.
Cultivate for weed control.
Plant lining-out stock.
Plant container stock.
Sow seeds in outdoor seedbeds.
Transplant rooted cuttings into outdoor beds and coldframes.
Apply fertilizer to field stock.
Remove polyethylene film cover from container stock.
Prune taxus, juniper, and hemlock, (first pruning; also in July.)
Ship orders for Middle Atlantic States.

May

Take softwood cuttings.
Stake and tie plants requiring support.
Cultivate for weed control.
Apply pesticides as needed.
Ship orders for Northern States.

June

Take greenwood cuttings.
Prune azalea, pieris, and rhododendron immediately after flowering.
Prune pines between June 15 and July 15.
Cultivate for weed control.
Apply pesticides as needed.
Ship orders for Northern States.

July

Prune taxus, juniper, and hemlock, (second pruning; also in April.)
Field-bud roses.
Cultivate for weed control.
Apply pesticides as needed.

August

Field-bud roses.
Cultivate for weed control.
Apply pesticides as needed.
Prepare catalog for December distribution.

September

Dig B&B narrowleaved evergreens.
Collect, clean, and store seeds.
T-bud nut and fruit trees in the field.
Prune spruces and firs.
Plant green manure crops on cleared fields.
Cultivate for weed control.
Ship orders for Northern States.

October

Dig bare-root and B&B stock for immediate shipping.
Dig bare-root stock for storage.
Root-prune trees and shrubs.
Collect, clean, and store seeds.
Apply selective herbicides.
Apply fertilizer to field stock.

October (Continued)

Sow seeds in outdoor seedbeds.

Stratify seeds requiring it.

Ship orders for Northern States.

November

Dig bare-root stock for storage.

Dig B&B stock for storage under polyethylene film cover.

Install polyethylene film cover over container stock.

Prune fruit trees and shade trees.

Take hardwood cuttings.

Fill orders for Middle Atlantic States.

December

Prune fruit trees and shade trees.

Take hardwood cuttings for sticking in the greenhouse.

Take and store hardwood cuttings of kinds for lining out in early spring.

Bench graft crabapples and store for spring planting.

Install rodent damage controls (repellants, baits, traps.)

Distribute catalog.

Fill orders for Southern States.

The Pennsylvania State University
College of Agriculture
Department of Agricultural Education
University Park, Pennsylvania

NURSERY PRODUCTION EXAMINATION

DIRECTIONS: Do not write on this test booklet. Use the separate answer sheet. Blacken out the letter of the most appropriate answer for each question.

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1. Nurseries that produce and/or sell stock to other producers and retailers but not directly to consumers:

   a. Landscape
   b. Retail
   c. Garden center
   d. Wholesale

2. Their development provides "one stop" shopping because they eliminate the necessity for stopping at a hardware store for seeds, fertilizer and hand tools, at an equipment dealer for garden equipment, and at a nursery for plants:

   a. Landscape nursery
   b. Garden stores
   c. Wholesale nursery
   d. Retail nursery

3. A nursery sales agent:

   a. is paid on a regular salary basis
   b. owns the nursery plants he sells
   c. functions as the sales manager for the firm
   d. is an independent salesman who receives commission for his services

4. The owner and manager of a nursery business is a:

   a. nurseryman
   b. nursery superintendent
   c. nursery foreman
   d. nursery production manager

5. The man in a nursery business who is responsible for starting new plants from seeds, cuttings, grafting, or by other means and also plans the propagation schedules:

   a. nursery worker
   b. propagator
   c. plant breeder
   d. stock man

6. The man who makes recommendations for fertilizer applications and pest and weed control measures:

   a. nursery technician
   b. nursery inspector
   c. nursery broker
   d. physical plant manager

7. This position requires a person to be familiar with the names, grades and sizes of plants, and also keeps accurate plant records:

   a. nursery clerk-typist
   b. stock man
   c. nursery production manager
   d. office manager

8. A nursery salesman is directly responsible to the:

   a. nursery foreman
   b. nurseryman
   c. nursery production manager
   d. office manager

9. The land, buildings, tools and machinery used in operating a nursery business is referred to as:

   a. supplies
   b. layout
   c. physical plant
   d. structures

10. The location of a nursery is generally on a gently rolling land or land with a slight slope rather than on low flat land because it:

   a. is more fertile
   b. accumulates cold air in fall and spring
   c. can hold more water
   d. has good air drainage

11. During winter, sheets of polyethylene film are placed over container nursery stock grown in beds to:

   a. maintain air curculation
   b. eliminate insect pests and diseases
   c. prevent sudden changes in temperature
   d. increase the supply of carbon dioxide and oxygen

12. A holding shelter is usually constructed in a nursery for the purpose of:

   a. displaying nursery plants
   b. preventing drying of the plants awaiting shipment
   c. providing space for grading and packing plants
   d. storing nursery equipment

13. The most important single item of large equipment in a nursery is the:

   a. spray equipment
   b. tree digger
   c. power tiller
   d. tractor

14. Materials such as sawdust, sand, vermiculite, perlite, peat, and ground bark are called:

   a. soil amendments
   b. fertilizers
   c. organic matter
   d. mulches

15. New pesticides that are placed in a storeroom should be dated:

    a. for uniformity
    b. for display purposes
    c. as guide for discarding old ones
    d. for name identification

16. Soil water and dissolved minerals are conducted up to stems and leaves through the:

    a. cambium
    b. xylem
    c. phloem
    d. epidermis

17. Plants lose water through holes in their leaves called:

    a. lytes
    b. nodes
    c. pores
    d. stomata

18. Photosynthesis is the process by which plants manufacture:

    a. proteins
    b. sugar
    c. fats
    d. vitamins

19. Which fertilizer ratios are recommended for most trees and shrubs?

    a. 2-1-1 and 1-2-1
    b. 1-2-2 and 2-3-2
    c. 2-2-2 and 1-2-1
    d. 1-1-1 and 2-3-2

20. Stems and roots of plants become larger in diameter by:

    a. photosynthesis
    b. cambium activity
    c. transpiration
    d. respiration

21. A chemical used to aid the formation of roots on cuttings is:

    a. applied after callusing
    b. sprayed on the propagation bed
    c. applied to the basal end of a freshly made cutting
    d. used to reduce infection

22. Which is a sexual method of reproduction?

    a. seeds
    b. cuttings
    c. division
    d. budding

23. Softwood cuttings are taken from:

    a. hardened wood from current season's growth
    b. unhardened wood from current season's growth
    c. hardened wood from last season's growth
    d. semi-hardened new growth

24. Cuttings root faster in propagating beds if the soil temperature is:

    a. about the same as the air temperature
    b. slightly below the air temperature
    c. slightly above the air temperature
    d. lowered about 10 degrees at night

25. The top part of a graft is called a:

    a. sperl
    b. shoot
    c. slip
    d. scion

26. Which weed control method is not recommended for newly propagated nursery stock?

    a. cultivating
    b. mulching
    c. preventing weeds from seeding-out nearby
    d. applying chemical controls

27. The framework enclosed with plastic film is commonly used to:

    a. root cuttings
    b. germinate seeds
    c. overwinter container-grown stock
    d. store cuttings over winter

28. The thin zone of tissue between the wood and the bark of a plant from which new tissues develop is called the:

    a. epidermis
    b. phloem
    c. xylem
    d. cambium

29. The main purpose of a green manure crop is to:

    a. increase the nutrients available to crop plants
    b. prevent soil erosion
    c. improve the organic matter content of the soil
    d. lower the pH of the soil

30. The need of plants for water is indicated by:

    a. slight wilting of the leaves
    b. yellowing of the leaves
    c. yellowing of the main shoot
    d. scorching of the leaves

31. Nursery stock is pruned to:

a. secure cuttings for next year's stock
b. prevent disease
c. reduce frost kill
d. induce compact growth

32. When should root pruning be done?

a. spring
b. summer
c. fall
d. winter

33. Small trees are lined out at what age?

a. 1-2 years old
b. 3-6 years old
c. 2-4 years old
d. 3-5 years old

34. Fruit trees are shaped to get:

a. as many branches as possible
b. 3-5 main branches
c. one main branch
d. two main branches

35. When is most bare-root stock to be dug?

a. fall
b. winter
c. spring
d. summer

36. "Heeling-in" is done to:

a. protect pruned plants
b. protect cuttings
c. protect roots of freshly dug plants
d. hold plants during winter months

37. What is the greatest advantage of growing nursery stock in containers?

a. no root pruning is necessary
b. greater production per unit of ground area
c. cultivation is easier
d. cost

38. Container-grown stock should be planted during:

a. early spring
b. early fall
c. summer months
d. winter months

39. Black polyethylene film is used to:

a. reduce weeds around containers
b. shorten the day length
c. prevent water loss from containers
d. wrap soil balls of B&B stock

40. What is the lowest temperature at which most troublesome weeds, insects, and disease organisms are destroyed by steaming?

a. $75^{o}F$
b. $100^{o}F$
c. $180^{o}F$
d. $300^{o}F$

41. When rooted cuttings are used for container stock, at what age are they planted into the containers?

a. 4 years old
b. 3 years old
c. 2 years old
d. 1 year old

42. No fertilizer should be added during August:

a. to prevent soft growth in fall
b. because soil test are taken in the fall
c. because of the heavy work load at that time
d. because the plants will not respond to it that season

43. Fertilizer may be most easily applied to growing container stock in the form of:

a. dry material
b. a solution
c. pellets
d. concentrated dry form

44. Container-grown stock is pruned to:

a. reduce frost kill
b. develop more shoots at tip of plant
c. induce compact growth
d. secure cuttings for next year's stock

45. Container-grown stock should be marketed:

a. when the plant is twice as tall as the container
b. when it is 2 years old
c. when it is 8 years old
d. when it reaches a standard grade size (but before roots form a mat).

46. The primary problem in shipping nursery stock is:

a. maintaining proper temperature and moisture
b. getting it to the customer on time
c. losing identity of the plants
d. obtaining quarantine inspection certificates

47. The nursery achieves its goals through good management of:

a. money
b. the physical plant, capital, and personnel
c. personnel and funds
d. cultural practices and techniques

48. The four stages in the cycle of solving management problems are:

a. fact collection, discussion, adoption, action
b. discussion, decision, adoption, evaluation
c. adoption, evaluation, change, reevaluation
d. planning, executing, controlling, evaluating

49. The three basic needs of all persons are:

a. food, clothing, shelter
b. physical, social, psychological
c. money, status, friends
d. faith, hope, love

50. The nursery activities most influenced by the season of the year are:

a. propagation, harvesting, shipping
b. planning, selling, ordering supplies
c. cost estimating, inventory control, repairs
d. maintenance, evaluation, problem solving

Answer Sheet for Examination on

NURSERY PRODUCTION

1. a b c d
2. a b c d
3. a b c d
4. a b c d
5. a b c d
6. a b c d
7. a b c d
8. a b c d
9. a b c d
10. a b c d
11. a b c d
12. a b c d
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